THE PRODUCTION ENGINEER—HIS WORK AND ITS EFFECT.

Presidential Address.

By Sir Walter Kent, C.B.E.

IT may appear a somewhat tactless proceeding on the part of one elected to the office of President of an Institution to raise the question of the utility of that Institution, but the existing tangle and the uncertain future of industry raise questions with which its work is intimately associated. Most things have within them the germ of the opposite effect to that for which they primarily exist. I trust, therefore, that I may be forgiven for putting forward some reflections on the question as to whether the production engineer has proved an unmitigated blessing. There appear to be three aspects of his work, first the furthering of British industry and commerce, second the flooding of the world's market by over production, third and perhaps the most important of all, how to combat the looming danger of competition from the cheap labour of the East.

He who runs may read the answer to the first issue. Viewed from the national and competitive standpoint the answer must unhesitatingly be in the affirmative; he has been our very salvation industrially and commercially, and may yet so continue in the mist-hidden future. Before the war the art of production had not been practised in England to anything like the extent that it had in America, largely because of the high price of labour in that country, and not perhaps even as much as in Germany, where the study of the perfection of tool and jig design certainly preceded the corresponding work in England by several years. But during the war the necessities of rapid and mass production of articles of all kinds, both heavy (as in guns and shells) and light and small (as in fuses) enforced the art upon English engineering practice, and a vast number of firms who had relied rather upon individual skill and somewhat antiquated, almost Heath-Robinson methods, were during and after the war, eager to avail themselves of the tremendous manufacturing advantage that the methods of the production engineer provided, and but for these methods we could not have regained that share of the world's trade that, with their aid, we have succeeded in doing.

As suggested in my opening paragraph, there can be little question but that the very salvation of the British industrial and commercial

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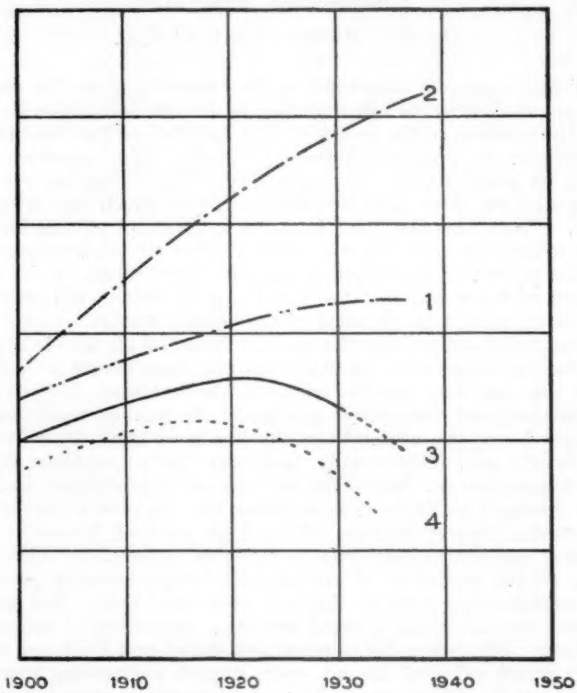
position depended upon the skill of the production engineer. But regarded from the wider standpoint of world commerce, may not the present disastrous slump be traced in very considerable measure to his only too successful efforts? When we endeavour to understand the reasons for the world-wide state either of actual or of provision for surplus production, the general conclusion to which



Curve 1.—Population of U.S.A.
Curve 2.—Output of Commodities.
Curve 3.—Number of worker days or hours to provide output.
Curve 4.—Probable number of workers required to supply current requirements of community.

the facts inevitably point, and which available statistics make certain, is that the production engineer is in great measure responsible for the condition.

Mr. G. W. Gray, A.R.S.M., has very kindly given me permission to quote a statement and to reproduce a diagram given in his presidential address to the Institution of Mining and Metallurgy.

This address deals with the manner in which production has outstripped both consumption and also the rate of increase of the population. Mr. Gray illustrates this by giving in diagrammatic form statistics prepared for the "Committee of Recent Economic Changes" and dealing with the four major branches of industry in the U.S.A. viz., agriculture, mining, manufactures, and railways. These show that between the years 1900 and 1920 an increase in total output of 70 per cent. was obtained, while the corresponding increase in workers was only 40 per cent. Then from the years 1920 to 1929 the increase of output was 25 per cent. while the number of workers to produce that output was actually decreased by seven per cent. The diagram (page 2) puts the whole matter in very clear form.

It will be noted that while the diagram is divided from left to right into periods of ten years beginning in 1900, no units have been specified for the vertical intervals, since the curves are intended to represent tendencies and not actual quantitative changes, and for the same reason breaks due to the war and the recent slump have been omitted.

Mr. Gray, in drawing conclusions that these figures appear to suggest, makes the grave statement that they "may imply a definite crisis in the affairs of humanity." It is, however, despite this (for reasons which I shall give later) that the production engineer, particularly the British, must redouble his efforts if we are to grapple with the situation that may arise in respect to the third issue, viz., competition from Asiatic nations.

According to the brochure published by the Secretary to the League of Nations the rate of production has increased more rapidly in America than it has in Europe, also in some European countries such as, for instance, Sweden, progress has been greater in the last few years than in England. This suggests somewhat urgently that the English production engineer has still a long way to go if we are not to be found behind should a struggle come, which unfortunately seems by no means impossible, for the survival of the fittest.

As has been pointed out by many writers, industrial effort must nearly always consist primarily of preparation for a demand that is expected, and frequently the work of the industrialist is even to create that demand by opening the eyes of the potential consumer to the advantage and necessity of employing apparatus for the purposes of his business or occupation, if he, the consumer, is not to remain stranded on the sands of time. In connection with this fact that the industralist is the pioneer of business, it is essential to remember that until the last few years a rapidly growing and increasing population has been available to create an ever-expanding clientele, but what may in the past have been relied on as an assured and natural increase of population and consumers, is to-day being

checked by many causes, positive and negative. For example, the population of Great Britain, which increased at the rate of 400,000 per annum in the eighties and nineties, is now increasing by about 130,000 persons. It is probable that in twenty years' time it may be declining.

In the United States, while the population in 1870 was 40 millions, in 1920 it was 120 millions, but from that date the curve has been flattening out so rapidly that a stationary and even declining population in the near future seems probable. The population of most of the other important white countries is exhibiting the same features.

Although the more equal division of wealth results in the spread of the amenities of life to almost the humblest classes of the population, and assists in providing a wider market, reliance must not be placed on this fact to counteract the absence of the expanding market hitherto provided by an increasing population. While the curve that I have given on a previous page shows an extraordinary increase in production per capita concurrently with the decline in the rate of increase of population since 1924, it must be remembered that production capacity per capita is increasing even more rapidly day by day owing to the assiduity and skill of the production engineer.

Before commenting on the remaining and probably greatest danger that the production engineer may have to surmount, it would be well, perhaps, briefly to re-state the three phases of his work and achievement. We seem to be confronted by a complexity of three main warring factors: (*a*) The upholding of British industrial efficiency; (*b*) the swamping of the world by the fecundity of production; (*c*) the vital necessity of bringing European or, shall we say, white-country production, to the very top notch of potential efficiency in order to combat the competition of cheap Eastern labour.

Some years before the war the German emperor stirred the world to an interested but half-amused tolerance by his dissertations upon the "Yellow Peril" which was, in effect, the possible invasion of western territory and civilisation by the countless hordes of China trained in military skill by the efficient Japanese. This danger does not appear imminent—not even likely. But is there not looming on the commercial horizon the dark cloud of an even greater and much more lasting danger, viz., not only the cessation of European and American importation into eastern lands, but the capture of the world markets including the very strongholds of trade in Europe and America by the Japanese utilising, and reinforced by, Chinese labour?

A shadow of the coming danger is shown by the following incident. A lady who has spent most of her life in India, and whose husband

occupies a high position in the Indian Civil Service, told me that she had bought in an Indian town a cotton tennis shirt of Indian manufacture, for one of her sons. This shirt was of high quality, thoroughly well made, and washed excellently, in fact a sound article, for the price of 2s. 6d. This was some fifteen months ago. But just before leaving India some nine months later she had, in the same bazaar, been offered a shirt of Japanese manufacture that appeared in every way the equal of the other for the sum of 1s. 3d. ! How can Manchester compete with this ?

In a paper read by M. Bankwitz, a director of a Polish cotton mill, at the recent International Cotton Conference at Prague, it was stated that from the years 1913 to 1932 the number of spindles in the cotton mills of Europe had remained practically stationary at 100,000,000, but the consumption of raw cotton had decreased from 12,100,000 bales to 8,700,000, while Asiatic spindles had increased from 9,100,000 to 21,400,000, and the consumption of cotton from 4,100,000 to 7,700,000 bales, or to nearly the same output as that of Europe. This high Asiatic output is due to the enormous disparity in the hours worked, as while, for instance, British spindles were working an average of thirty hours a week, the Japanese, with the aid of double shift, were working 102 hours! Moreover, Japanese labour is only about one-third the price of British labour, and when with this the great reduction in on-costs due to the longer hours worked per week is taken into account, the hopelessness of competition becomes apparent and, moreover, these operatives, though cheap, are not "nasty," their work being described as most efficient. This brings one to the consideration of "raw material" costs. We talk of labour and raw material. Is not the latter a gross misnomer ? Except the air we breathe and the sea we sometimes bathe in, is there any raw material utilised as such ? Therefore, in considering the lowering menace of Eastern competition, we must regard all costs from the labour standpoint except where raw material has to be purchased outside.

Is it to be expected, if success is achieved in the direction in which the attempt has already been made, that the enterprising Jap will not gradually extend his efforts to all spheres of industry ? Already in another department a mechanical appliance that is largely used for waterworks' purposes, and which some ten years ago commanded an average price of about £2 10s. is now being sold in Japan for a sum equal to 6s. 0d.

While the methods of life of the eastern and the western lie so far apart, how can a wage approaching equality be possible ? Contrast the food of the Japanese, rice and perhaps a little fish, as against the varied and expensive diet of the English working man. And then again take the Japanese house, sheets of parchment in light wooden frames, with the minimum of furniture. How much

cheaper than the English artisan's house built with most expensive labour doing a regulated minimum of work.

While the advance in civilisation, with its ever-increasing requirements both in the quality of food and clothing, amusements, and general amenities, may result in a substantial increase in the cost of Eastern labour, it requires an utter metamorphosis of their whole habit of life, indeed of their mentality, to conceive any change that would bring about a parity.

The problem presented by these disturbing facts is one of the utmost difficulty. Broadly it would be expected that to supply humanity with the necessities of life at the lowest cost was a beneficent work, but if, by so doing and redundantly duplicating the machinery of production, the large section of the population of the world hitherto engaged therein would be deprived of their occupation, then the process would not seem quite so kindly. An attempt has been made by South Africa, India, Holland, and other countries to curtail Eastern competition by tariff barriers, but unless such goods are to be entirely excluded from the market of those living on the higher plane of European civilisation, is it to be expected that any tariff can be efficient for the purpose?

What is the remedy? What can the production engineer do to stem the tide of this invasion? So much has been done already in reducing costs, that doing, as no doubt he will, his uttermost, there appears little hope of competition on a price basis with the products of the East. To cope with the situation towards which we are drifting, lower wages and longer hours, and every possible device that the production engineer can conceive to reduce costs, seem imperative. But lower wages and longer hours seem to be setting the clock back and to be stultifying the beneficent tendency to lighten labour and shorten hours.

Sir Gowland Hopkins, in his recent presidential address to the British Association, spoke of the "beneficent machine"—a *façon de parler* of the work of the production engineer—and envisaging that carried to its ultimate limit would mean the work of the world being executed by machines and not by men, and that the problem of the profitable employment of excess leisure would arise in acute form. It was suggested by Sir Gowland that a "House" of the finest intellects available should be constituted in order to devise means suitably to occupy these idle hours. Unless the requirements of the new state of society thus created would call for appreciable increases in production, which would tend to employ more people, even if much of the work were machine-made—the final condition would consist in a very great increase in the leisure hours of the world at large. Unless human nature is greatly altered, it is difficult to conceive that this time will be expended to the benefit of humanity. The natural tendency on the part of many

would be towards a plethora of road houses, greyhound stadia, etc., and the small percentage who would pursue art, literature, or science, would add but little to leaven the mass. Moreover, there would be the further danger that the idle time made demands that the purse could not meet leading to discontent—the door to unrest and civil disturbance. And could any "House" devise a better pastime than honest labour?

The future seems to be threatened both by the Scylla of too intensive production for existing requirements, and the Charybdis of inability to meet the competition of the cheap labour of the East. Whether the safe course will be found at all and, if so, whether by the politician or the business man, is beyond even conjecture on my part.

It may, perhaps, seem to be wanting in initiative merely to point out dangers without suggesting a means of combating them, but the whole question is so involved, and the opinions of thinking men so divided, that it would seem that a way may only be found as a result perhaps of "trial and error" or perhaps by some revealing flash of genius.

While I wish with all my heart that I could suggest a panacea for the evils that now confront us, perhaps in self-defence it is only fair to state that I wrote to the head of the statistical section of a certain association which should be in the best position to give information on the matter in question, and was by him given the names of some half-dozen books written by various learned political economists, to which list he added the comment that he ought to say that all these authorities differed from each other! Moreover, to give a solution to one of the greatest problems that have faced civilisation would be to answer the enigma that is engaging the attention of the best brains of almost every country of the world.

Meanwhile, the obvious duty of the production engineer is to perfect his art to the very highest, and to put our country in the forefront of industrial efficiency. He should be keenly concerned with the training of the men of to-morrow if his own national existence is to be preserved. A very striking example of the importance of this may be found in the position of Switzerland where they have made a careful study of and have taken the utmost pains with the training of men—their most valuable and essential asset. Switzerland lacks many of the advantages we possess—no shipping, no cheap sea-borne freights, no coal, iron, or other metals. Water power she has, but little save that and the highly trained labour which seems to possess hereditary skill passed down from father to son. Only in this way is such work possible as that done by the firms of Robert Sulzer and the Société Genevoise, and in their great watch-making industry, which are examples of what scientific

production can achieve despite the lack of other competitive advantages. I would therefore suggest that perhaps the most valuable work that can be done by this Institution lies in the training of its younger members, that the best available brains may be properly prepared for carrying on the torch of progress.

May we be permeated by the spirit of Admiral Duncan who, when beset by very greatly superior forces off the Texel, signalled from his flagship: "I have taken the depth of the water—if my ship sinks my flag will still fly!" His ship did not sink, and neither shall ours!

TENTH ANNUAL DINNER OF THE INSTITUTION.

THE tenth annual dinner of the Institution was held at the Holborn Restaurant, London, on Friday, 20th October, 1933. Sir Walter Kent, C.B.E., President, was in the chair, and there was a large attendance of members and visitors. The toast of "His Majesty the King" having been duly honoured, MR. A. E. CHORLTON, M.P. (President, Institution of Mechanical Engineers) said: I have been asked to propose the toast of "The Institution and its President" though I must confess I do not quite know why, for I ceased to have anything to do with production engineering long ago. I was rather taken aback to be told in the reception room that serious speeches were not allowed, and that one must tell a number of tales. Gentlemen, I am not prepared to tell a number of tales on such notice and before such distinguished company. No doubt, had I been a member of one of the smaller tables I might have taken my share!

In honouring the toast to your Chairman I should be serious. This Institution of yours is really one of those of which there are quite a number who have sprung from the Institution of which I have the honour to be President. There are all branches of mechanical engineering, and there is little doubt that if some years ago those in charge, who sat in the seats of the mighty, had foreseen the development that mechanical engineering was going to make in the realms of manufacture they would have devised more elastic means to meet the case than they have done. They did not foresee the tendency to form new institutions. It is very curious to me this tendency, not only in the case of institutions and so on, but actually in industry and in life generally during the past. We have had during the Victorian time and the succeeding years up to the war always an example of individualistic development—always has it been a question of development by separation one from the other. Every man evidently had the feeling in his breast that it was best for all, he himself and the State, if he should leave where he was and start on his own. The whole country has been built up on these lines. The towns have also, as well as the industries—the whole of the services of each town were developed entirely on their own. To-day we seem to have come to a time in which there is a distinct return swing of the pendulum. The old individualistic days have not disappeared, but at any rate they have very greatly changed, and now we see, so to speak, an age of contraction. The other was

expansion, or if you like centrifugal, now on all hands there is this increasing tendency to join together and act together in contrast to what used to be done in the days of expansion. This is, I think, shown to a remarkable extent in the oldest industry that we have in the country—agriculture. You see to-day group control with absolute powers throughout, all of which has been accepted with very little opposition from the old and most conservative industry in the land. What does it mean? Is this a sign of the times? Are you going to have to face in the ordinary mechanical industries similar grouping and control? I doubt it, but on the other hand I believe some of the industries of the country will have to. I suggest, for instance, that the cotton trade is one of the most individualistic industries that we have in the country, and because of this characteristic it is suffering very greatly in its inability to act with one voice. It is quite likely that ultimately the only way they will achieve success will be by acting together, to bring about a better state of efficiency, but under the compelling powers of a central control body. I do not want to carry this too far, but I do think it is a subject that might engage your attention. We have little of it, if any, in the mechanical side of industry to-day. Possibly coal is the only industry which has it.

May I just refer to one portent in the sky to-day which has given me and others great concern—perhaps it has not yet come into your ken, and that is Japanese competition? All those Members of Parliament who sit for cotton districts have had brought home to them the absolutely overwhelming nature of the competition from that country. It is probably the greatest commercial menace that we have had to face in our time. You can take it that as Japan is a proud and empirically minded nation with a rapidly expanding population—a nation determined to control as much of the world as she can—it is more than likely that we shall see the same development in competition with our ordinary engineering industries that we see to-day with regard to cotton.

I just referred to this matter because I do hope that a lot of the people who are not directly concerned in the industries that are suffering to-day will at any rate give their help to us in order that we may be able to get something done by the Government.

Now may I turn to a little of my own experience? First, my contact with production engineering began before the war. I was a works manager, and I think one of the few in the early days who began to plan in the workshop and in the costing systems that were then adopted, the premium bonus and so on. It was a vastly interesting time. There was very little to go on, but we did get some quite remarkable results. I am sorry that my contact with the manufacturing side of engineering is now but a thin one, but

I still remember happy days of production engineering and works planning.

Looking at the work that you undertake yourselves, in the syllabus that the Secretary has kindly sent to me, I find that nearly all lectures are concerned with mechanical engineering manufactures in one form or another, and I am a little puzzled why that should be so. If I am wrong I hope you will correct me. Production engineering, or the science of production, surely must enter into all industries. Why, for instance, are there no representatives here to-night of a branch of your Institution concerned with the cotton trade? If the success that you have achieved in the production, say, of motor cars could be translated into cotton, then we should have far less reason to fear Japanese competition, and so I hope that you will extend your spheres of activity to cover various other industries. I think there is a vast field for your work, not only in production but even in consumption. It is said that production has far exceeded the consumption of the world. That is our difficulty. It is really an admission by economists and politicians and social service people generally that they have failed in their job. I only hope, therefore, that your ambitions will extend and that you will enter also into these other services of consumption as I have indicated.

Now may I close by asking you all, gentlemen, to drink to the health and prosperity of your Institution, coupled with the name of your worthy President, Sir Walter Kent.

The toast was duly honoured.

Sir Walter Kent, C.B.E. (President): First I feel that it is not only my bounden duty but my most sincere pleasure to thank you most heartily for the high honour that you have done me in electing me to be your President. I feel in following a man of the achievements of Sir Herbert Austin that that duty is no light one. In one thing alone I cannot acknowledge his superiority and that is in the desire in every way to further the purposes of this Institution. It is hard for me to say how much I thank you, but I do want you all to understand that I say it from the bottom of my heart, and I trust that when my year of office comes to an end you will not have found me wanting in effort. We see the wonderful results that Sir Herbert has achieved during his two years of office. He has been backed by so many loyal workers in all branches of the Institution, and, while, perhaps it is not fair to mention names because there are so many that should be mentioned, there are one or two that are outstanding. There is the Chairman of the Council, Mr. Carlton Smith, Mr. Hutchinson, and last but not least, Mr. Hazleton. I think to these three gentlemen we all owe very much, and I believe that with the work they have done, with the wonderful increase that we have seen during the past two years in membership, in the number of lectures,

in the discussions that took place—discussions where so much thought has been displayed—we may now know that the Institution is well launched upon a career of even greater usefulness in the future than it has hitherto experienced. It was my good fortune to be at Manchester some ten days ago where a very wonderful paper was read by Mr. W. L. Hichens, and I think between five and six hundred people were present at that paper, after which there was a discussion of great interest. The whole thing showed that in the Manchester area the production engineer was fully alive to his responsibilities and duties and that the work of the country so far as he was concerned would certainly not be neglected for want of concentration. I feel that there are many other parts of the country that might well emulate Manchester, and I hope that at the end of this year we may have a record of attendance at the various meetings that will surpass anything that has happened hitherto.

In referring to Sir Herbert Austin I could not help but remember the experience of a friend of mine who, going along the Great North Road in a Rolls, saw in front of him one of those wonderful little cars designed by Sir Herbert, known as Baby Austins, which now and then was giving a queer sort of jump. My friend could not detect anything on the road to account for this, and with some effort, even on the part of the Rolls, he overtook the Austin and pulled up and said, "Excuse me, but I think there is something the matter with your car." The voice inside said, "There's nothing the matter with the car, but I've got the hiccoughs!"

You have on your programme "Response and Presidential Address" by me. I think you have already been sufficiently bored by the printed copy of my address so I do not propose to inflict any more of that upon you, except that I would like to make, with your kind permission, one short comment on the remark just made by Mr. Chorlton, and that is with regard to the trade of Japan in cotton goods. I gave in that presidential address an experience of a lady friend of mine who bought in a bazaar an Indian shirt for 2s. 6d. which she had sent to her son and which had proved admirable in every way. That was a year ago. Some seven or eight months later before coming home, in the same bazaar she bought a Japanese shirt for 1s. 3d., and she told me that the worst of it was that the cotton with which that shirt was made was grown in India, sent to Japan, made into a shirt and brought back and sold at half the price of a similar Indian article. But the point I wish to make is this, that with Japanese labour at something like a third or fourth of the labour here I do not think that it very much matters what the production engineer does. Manchester will never be able to produce a shirt at a corresponding price, particularly considering that to-day

Japan is actually making spinning machinery and selling it to other countries—a prerogative which used to belong entirely to Lancashire.

So that the problem that I have attempted to explain in the presidential address that I have had the temerity to put before you in print, is one of great complexity and difficulty, but I have tried to present it as a word of warning to arouse us to fresh efforts, but what the way out will be I do not pretend to know. I am not like the Member of Parliament who in the House of Commons one day said, "Upon the untrodden paths of the future I can see the footprints of the hidden hand."

May I be allowed one earnest word in conclusion? It is that whatever may be the odds against us we must keep good heart, we must do our utmost to improve the art of the production engineer and I am confident that this Institution, especially if it devotes its energies to training the young idea, by example, by precept, by these examinations which are being extended very admirably and to most excellent purpose, will have rendered England yeoman's service. The greater the skill we can get in the rising generation, the better will be our position in the race for the commerce of the world, and I think there is no body of engineers, civil or mechanical, no matter how venerable—even if we go back to the father of all engineering institutions, the Smetonian Society—whose work can help England to the same extent as that of the production engineers because through them we arrive at the lowest possible cost consistent with the highest possible efficiency.

Sir Herbert Austin, K.B.E., J.P. (Retiring President): I am down on the list to propose the toast of "The Guests"—a very time-honoured toast. It would be almost impossible to find when the first toast of "The Guests" was made, but it is a very ancient one and on this particular occasion I take particular pleasure in being allowed to propose it, partly because of the guests that we have with us this evening and also because I shall feel in the future more of a guest than a President of the Institution. We have a number of influential gentlemen who are our guests this evening. Looking through the list I see no reason whatever, either from the point of view of their general occupation or from the positions that they hold, why they should not become members of the Institution. I suggest that most of them might be members with us of an Institution which they would honour by their attainments. I mention first Mr. Chorlton. He is a Member of Parliament—I cannot say very much for him in that direction (laughter)—but with the best wish in the world to help the Government I have a memory of four years I spent in the House of Commons, and when I was asked a little while ago if I would stand again for the same constituency I said—not on your life! At any rate if I do not think I can say very much for Mr. Chorlton in that direction—perhaps I might sympathise with him.

He is a man of common sense and I am certain that at various times in sitting in the House he must be terribly bored.

He is also President of the Institution of Mechanical Engineers, and I noticed in the speech he made this evening that he could not refrain from adopting the "grandfather" attitude. We are very young children in this Institution and we must put up with fatherly consideration. As I am also a member of the Mechanicals I should say something nice about him. I should like to congratulate Mr. Chorlton on being President. It is a very honoured position. It carries a good deal of responsibility and it is something to look back on having been President of such a big institution. I agree with him that the failure of the older institutions in not having made their ranks wide enough in membership to incorporate all kinds of engineers, was no doubt a very grave fault. In any case we feel very highly honoured to Mr. Chorlton in having him with us this evening and particularly as representing such a very influential institution and one to which we are very nearly allied.

Then we have Colonel Restler, President of the Engineers-in-Charge. As President of the Engineers-in-Charge he holds a responsible position and one which no doubt carries with it a good deal of work. There is no reason why we should not try to get Colonel Restler to join our Institution. I do not know whether production engineering enters into the work which the Engineers-in-Charge do, but at any rate I am sure that in the production of machinery with which they have to deal it would not do that side of engineering any harm if they looked on their particular work from the same point of view as the production engineer.

We have also with us the President of the Institution of Automobile Engineers, Mr. C. R. F. Engelbach. I could say quite a lot about him, but he is down to reply to my toast, so you must excuse me if I do not say anything further. Some of you must know him quite well and it would be quite unnecessary for me to add to that knowledge.

We have also with us two editors. I have always had a very great respect for editors, and more particularly for editors of engineering magazines or journals. We have Mr. Allen, editor of *Machinery*, one of the papers I suppose every production engineer looks at, and Mr. Chubb, who is editor of the *Machinist*, another of our trade journals. There are quite a number of other guests but I am not proposing to mention any others.

I have been associated with this Institution for some years, and I have had the honour and pride of being President for two years. During that period I am afraid I have had the credit of doing a great deal of work that has been done by somebody else. I feel that in this Institution and in others the Presidents always get a lot of praise for work done by those who are officials of the

Institution—the Secretary, the Presidents of the Sections, and various other people who give a lot of time and attention and a great deal of ability to the work that is needed to keep the Institution together. Without them I am perfectly certain this Institution would not have attained the position which it holds to-day.

During my presidency there have been no less than five new centres established, and we have now 11 centres—quite a remarkable achievement in the history of institutions of this kind. I believe that the Institution of Electrical Engineers has 13 centres (it may now have one or two more), but at any rate we must be climbing up very close to the top, and I see no reason, if we have in the few years that we have been in existence got to 11 centres, to doubt that we must be travelling at a speed very much greater than any of the older institutions. There is no question that this spreading of our work to the various centres is going to be a way in which we shall be able to exert far more pressure on those who are concerned with our work than if we were to try to centralise in London and only have occasional meetings in the country. Our various centres are not dependent on a London organisation. They are all equal. You have a local President of each centre and you allow them to carry on and to show their individuality and the way in which they can handle the work required in each case, and develop according to the ability and the way in which the centre is governed. I think that is one of the big reasons for our success, and I hope that it will be pushed forward. There are still quite a number of centres where we can establish an organisation which will bring in a great deal of help and credit in the future.

You heard from the President a few minutes ago that we had a meeting in Manchester about ten days ago at which over 500 people attended. That is remarkable. It was no doubt a special occasion, but if we can get 500 people to a meeting in Manchester once there is no reason why we should not get 500 every time. It is only necessary to have the interest created by the person who is going to speak. Other centres, of course, may not be able to bring so many people together, but it was a very wonderful meeting and I should imagine that anything from 250 to 500 at a meeting must be coming very close to a record.

I noticed with considerable interest that our President in his Address led off with some references to thoughts he may have had as to the number and need of new institutions. I have mentioned on a former occasion that I had exactly the same thoughts. When it was first mooted my reaction was : " Why do we want another institution ? Surely we have enough institutions ; why another ? " I must admit, and I am sure that Sir Walter will admit, too, by the time he has finished his year of office, that there is every justification for this institution. I have been surprised with the progress

made. It has shown that it was wanted. It is of great interest to some section of the community, and the speed with which it has grown shows that it might with advantage have been formulated many years ago. It is a great credit to everyone concerned.

Two of our speakers to-night have dealt with this question of Japanese competition. There is no doubt that it is a serious matter. It is one of those things that grows quietly away from the main centres of interest. Japan to-day, as it has always been, is rather a mystery to us. Things happen in Japan that we do not quite appreciate, but it has got one thing that some of the nations in the world have not—it has a very strong national feeling. There is no doubt that this feeling which has been created by Hitler in Germany will carry on. My opinion is that you will see a very considerable change in the face of Germany and the power which it will yield in the future. It has stirred up national feeling and we have seen instances of that when national feeling has been raised in this country. The result in this country would be just as effective, but when you deal with the question of the United States—the man who can create a national feeling there would be somewhat of a magician. Whatever the possibilities of Germany at the present moment I have very grave doubts as to what is going to happen in America, and although we fear some industries in this country may suffer from competition in Japan we may have to fear competition from Germany in other industries. There is no doubt that if America follows the line of least resistance and goes in for further inflation, which appears to any thinker as the kind of thing that is bound to happen and the only way out, it will make a very difficult position for us who manufacture in this country. I fear at the moment much more from what may happen in America than from what may happen in Japan. On the other hand Japan has got into a position where it would take a great deal of serious thought and a great deal of very careful preparation if we are going to try to compete with her. At the present moment with regard to cotton goods she is making 35 per cent. of the manufactured cotton goods in the world, and it is estimated that in a very short time she will make 50 per cent. That is very bad for the cotton industry. I am not so concerned with the cotton industry because although we use a certain amount of cotton we are dealing with something else that is much more interesting. I should hate to think of the time when Japan starts to build motor cars ! At the present time she is exporting parts of motor cars. I had a visit from an Australian the other day and he is at the moment making something like 90 per cent. of the pistons, boring cylinders, and making piston rings for the trade in Sydney. One of the reasons why we do not send spare parts to Australia ! But they do not fear Americans or the English ; they seriously fear the Japanese. Japan is producing and sending over and selling to the agents piston rings

for 1½d. each. I dare say that figure has been very closely touched by some manufacturers in this country, but you have got to pay a duty into Australia, and I should imagine the price of those piston rings obtained by Japanese manufacturers would not be much over ½d.

Whatever the position the production engineer may occupy at the present moment, in the order of things he is likely to occupy a very much more responsible and important position in the future. I think that any work that this Institution can do in the way of raising the quality, imparting the necessary knowledge, giving the facilities to our production engineers to try to keep the trade of this country on its legs, is something worth looking after, and I do really feel that whatever you may individually and collectively think about the value of your position in industry to-day you will probably in ten years time be able to consider it a very much more important position altogether. I give you that feeling because although it may not mean that because you are carrying bigger responsibilities you are going to get bigger salaries—that may not be the direction—but you will have responsibilities as well as the work, and knowing what I do of production engineering you have nothing to complain about the monotony of what you have got to do. There are lots of jobs much worse, and you should take a pride in your work. You have got something to show for what you have done. Whatever you do it is possible for you to take a very great interest in, do everything you possibly can to make it better, and I would suggest that in a very few years the production engineer in this country will occupy a very much more important position that he has in the past.

I have still got to ask you to charge your glasses, and I would like to say this, that the visit of our guests this evening will, I hope, give them a good impression of the value of the Institution in general, and I would repeat my suggestion that they might with perhaps advantage to themselves and certainly with advantage to the Institution, join us and become members. I ask you to arise and drink to the health of " Our Guests."

The toast was duly honoured.

Mr. C. R. F. Engelbach (President of the Institution of Automobile Engineers) : I have got the thin end of the stick, being the last speaker, and also I am in a very difficult position because I have so many rôles to fulfil. I am a member of this Institution but I am also a guest. I also am replying on behalf of the Institution of Automobile Engineers, of which I have the honour of being President.

As President of that Institution I extend to you, Sir Walter Kent, our very cordial greetings and congratulate you on being made President of this very flourishing Institution. We congratulate you on its progress, but our congratulations are somewhat tinged with envy because of your youth and virility. You have

made such great progress that we must look to our laurels although you deal more with the practical side of engineering, whilst perhaps we suffer from too much " X " appeal. I, as a member of your Institution, however, am very proud of its achievements.

I was glad to hear that Sir Herbert did not like to say much about me. I am glad for his sake because I could have said a lot about him, but you must not judge him from the kind way he has been talking to you to-night! He speaks quite differently when I tell him we can *only* produce 2,000 cars a week.

I do not want to take up your time, but I did, in my own Institution, try to represent that production engineers were paying too much attention to the speed of operation rather than the " material " side of the question, and that as materials formed a bigger proportion of our costs than labour, more attention should be paid to that side of our business. It is getting very late in the evening, so on behalf of the guests I should like to thank you for your very great hospitality to us and the charming way in which Sir Herbert made his remarks about us. We feel very much elevated, not only by your kindness, but also by the good things you have given us, both to eat and to drink.

Mr. H. A. Hartley: Gentlemen, I am sure that we should not like this happy evening to end without expressing to our President our very warm thanks for the way he has presided over us to-night and the words he has addressed to us. Sir Herbert Austin for the past two years has served our Institution as President, and we all agree that in Sir Walter Kent we have one who is going to worthily follow in the steps of Sir Herbert. We wish you, Sir Walter, the very best of years, a great deal of happiness, and that under your guidance we may see production increase, costs decreased, and profits more plentiful. I have much pleasure in asking you gentlemen to join in warm acclamation and thanks to our President, especially for his help to-night

Sir Walter Kent: I tried unsuccessfully to stop this last toast, but I am nevertheless most deeply grateful to you for seconding the very warm way in which Mr. Hartley was good enough to propose the toast. All the thanks I needed for any little thing I may have done have been given me by your very kind applause.

TWELFTH ANNUAL GENERAL MEETING, AND EXTRAORDINARY GENERAL MEETING.

THE twelfth annual general meeting of the Institution was held at the Holborn Restaurant, London, on Friday, 20th October, 1933, at 6-0 p.m.

Sir Herbert Austin, K.B.E., President, first presided.

Mr. R. Hazleton, General Secretary, read the notice convening the meeting, and after the minutes of the previous annual general meeting had been confirmed and signed, the result of the annual elections to the Council for 1933-34 was reported.

Sir Walter Kent, C.B.E., then took the Chair as President, and a cordial vote of thanks was adopted to Sir Herbert Austin for his services as President during the previous two years.

On the motion of Mr. R. H. Hutchinson (Past President and Chairman of the Finance and Development Committee), seconded by Mr. A. J. P. Soar, the Annual Report and Accounts for 1932-33 were adopted.

On the motion of Mr. E. J. H. Jones (President, London Section), seconded by Mr. S. Gilbert (Member of Council), Messrs. C. H Appleby & Co., Chartered Accountants, were re-elected auditors.

The proceedings concluded with a vote of thanks to lecturers and Section Hon. Secretaries for their work during the previous session.

Following the annual general meeting, an Extraordinary General Meeting of Members was held to deal with alterations to the Memorandum and Articles of Association recommended by the Council.

On the motion of the President, seconded by Sir Herbert Austin, the alterations were unanimously adopted.

JIG AND TOOL DESIGN.

Paper presented to the Institution, London and Eastern Counties Sections, by E. J. H. Jones, M.I.P.E., President, London Section.

Approach.

I FEEL sure you will agree with me that to read a paper in a little over one hour, the title of which covers so vast and diverse a subject, is rather a presumptuous undertaking, and I accepted the Institution's invitation with some diffidence. I resolved, therefore, that to cover sufficient ground to make this paper of use, reference to certain aspects must be omitted altogether.

No reference will be made to the elementary jig, commonsense and little experience can evolve the simple types. The extreme opposite, mass production tackle, is featured more in the technical press than the types of jigs and tools more generally in use. I have, therefore, refrained from concentrating on examples in this direction. These are, no doubt, of certain interest, but companies in the position to use such equipment can be counted on the fingers of one hand and, after all, the same principles are used as are applied to the single component fixture.

The examples which I am showing emphasise novel or useful features which have been tried out with success and, in explaining them, an outline of the principles and construction used will be given. I hope and anticipate that the slides will be clear enough to enable you to follow the detail, and show how various problems presented to the jig and tool designer were overcome. Also, as far as possible, the examples chosen are not applicable to one component alone, or to one section of the trade, but are such that they can, I believe, by adaptation, be used on varying types of work. Also, in the time allotted, I cannot go into the position of the economics surrounding the use of jigs and fixtures. This is a question, for the most part, either of simple arithmetic, or business courage and foresight.

Apart from two examples of complete presses designed for special purposes, no reference will be made to press tools. A paper on this subject is being given this session in our Coventry centre. In order to cover as much ground as possible, a few examples have been taken from each type of machining, i.e., milling, drilling, turning, boring, grinding, air chucks, and miscellaneous items, together with a few examples of the adaptation of standard or obsolete machine tools to

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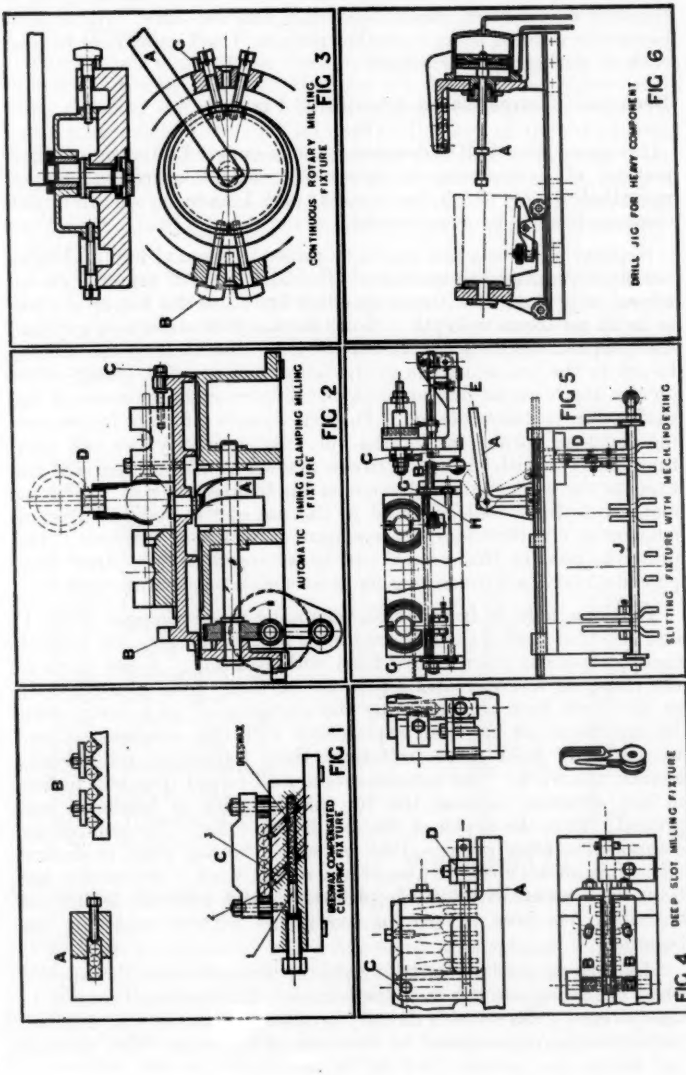
London, 6th October, 1933; Ipswich, 6th February, 1934.


BEESWAX COMPENSATED CLAMPING FIXTURE
FIG 1
AUTOMATIC TIMING & CLAMPING MILLING FIXTURE
FIG 2
CONTINUOUS ROTARY MILLING FIXTURE
FIG 3
DEEP SLOT MILLING FIXTURE
FIG 4
SLITTING FIXTURE WITH MECH. INDEXING
FIG 5
DRILL JIG FOR HEAVY COMPONENT
FIG 6

special purposes. The examples are, of necessity, limited, but if there is any part of this subject not touched upon, which is of particular interest to any member present, I will endeavour to deal with it during the discussion.

Beeswax Compensated Clamping Fixture.
(FIG. 1).

I propose first of all to describe what has proved to be an excellent method of overcoming an apparently simple operation, but is nevertheless one which has caused, and I have no doubt is still causing, trouble in many works.

Suppose a flat or a slot has to be milled in a round bar, and there are large quantities to machine. The bars, we will suppose, are all turned or ground to within a specified limit and the flat or slot has to be to an accurate depth. Now, we can slide these in a gap and screw up on the ends (as shown at *A*) in which case some will be forced to the top and some to the bottom of the slot, giving errors on the depth of the flat equal to the differences in diameter of the shafts, due to the tolerance. Further, there is difficulty in preventing the bars turning under the cut. Alternatively, we can drop them in vees with clamps between (shown at *B*) and increase the time for the work, because the cutter has to cross the gap. A better method, I think, will be found in the use of the hydraulic fixture (shown at *C*), the clamping medium of which is beeswax. The principle used in this fixture can be arranged to suit other components, and I am describing its most simple application only.

The long hole in front of the clamping screw plunger (item 1) and also that part of the holes not filled by the clamping pin beneath each component (item 2) are filled with beeswax. A few turns of the clamping screw creates a pressure on each of the pins (item 3), at the same time compensating the clamping of each component. No trouble at all has been experienced with this arrangement and we certainly hold more uniformly than tightening individually against the work. The components are all forced, you will notice, in one direction against the top plate, which is hardened and ground ; thus the depth of the slot is controlled. To remove the components, after releasing the pressure, the top plate is slacked off. This allows space to assemble a row of work. No trouble has been experienced with leakage of beeswax and a fixture as the one described has been in use for four years without replacing the beeswax.

The following reference to simply hydrostatics may be applied when designing a fixture on these lines. The pressure created in the system by the screw is directly proportional to the load applied, but inversely proportional to the area of the ram. The load on

each pin clamping the work is directly proportional to its area for a given pressure.

Should your components vary in thickness, ensure that there is sufficient traverse in either direction on the clamping screw, and when choosing the ratio of the diameters, remember that the idle linear movement of the ram is equal to the sum of the volumetric displacement of all the pins, divided by the area of the ram. On the arrangement shown, assuming three tons on the screw, using a 20-in. wrench, a pressure of 9.75 tons per square inch is obtained, resulting in a load on each pin of 1.18 tons at 80 per cent. efficiency in the unit.

The following are the actual loads transmitted by various diameters of screws using the standard spanner. The tests were made on the Buckton machine and are the average resulting from a comfortable pull of two individuals weighing nine stone and 11 stone, respectively.

		Length of Wrench inches	Tons average
$\frac{1}{4}$-in.	B.S.F. bolt	4	1.20
$\frac{1}{4}$-in.	Whitworth bolt	4	.96
$\frac{5}{16}$-in.	B.S.F. bolt	4	.91
$\frac{5}{16}$-in.	Whitworth bolt	4	.86
$\frac{3}{8}$-in.	B.S.F. bolt	$5\frac{3}{4}$	1.5
$\frac{3}{8}$-in.	Whitworth bolt	$5\frac{3}{4}$	1.46
$\frac{7}{16}$-in.	B.S.F. bolt	$5\frac{3}{4}$	1.35
$\frac{7}{16}$-in.	Whitworth bolt	8 W.	2.3
$\frac{1}{2}$-in.	B.S.F. bolt	8	2.1
$\frac{1}{2}$-in.	Whitworth bolt	8	1.82
$\frac{5}{8}$-in.	B.S.F. bolt	9	2.8
$\frac{5}{8}$-in.	Whitworth bolt	9	2.8
$\frac{3}{4}$-in.	B.S.F. bolt	9	2.4
$\frac{3}{4}$-in.	Whitworth bolt	11	2.1
$\frac{7}{8}$-in.	B.S.F. bolt	12	2.7
$\frac{7}{8}$-in.	Whitworth bolt	12	2.65
1-in.	B.S.F. bolt	(16 two-handed)	5.8

Automatic Timing and Clamping Milling Fixture. (Fig. 2).

This is an arrangement which has many applications, but in the instance to be described is used for cutting the slots in the heads of valves. The fixture is self-clamping and its movement to and from the cutters is automatic. It is, of course, used on a small horizontal milling machine, the table of which is locked, and the two fixtures, one on either side of the four cutters, are moved to

and fro on a box bed and are given their relative travel by a cam shown underneath, at *A*. A roller, which runs in the cam track, is fixed to a sliding member *B* to which the fixtures are bolted. The cam is driven through worm and gear reduction from the machine's telescopic feed operating shaft. The two fixtures are adjustable for depth of cut by the screws *C*. The valves are dropped in slots on the fixture, the chamfered heads seating in a recess.

Beneath the steady arm of the machine is bolted a block *D* on which eight sets of leaf springs are fitted, and as the components travel towards the cutter the springs hold them in position ready for the cut, whilst on the other side of the fixture the springs are away from the work and the component is lifted out.

Continuous Rotary Milling Fixture.

(Fig. 3).

This type of self-clamping milling fixture has many applications, such as the milling of two flats on pins, or bolt heads, or sawing collars into two pieces, etc., and is bolted to the rotary table of a vertical milling machine.

The whole of the fixture revolves with the table, with the exception of the centre pin. This is prevented from rotating by a bar *A* fixed to the machine table and located over the top of the pin in a "DEE" shaped hole. The two diameters on this centre pin are eccentric and you will readily appreciate that the top portion of the fixture, which is steel, is strained on the one side during rotation, thereby pulling the clamping bolts *B* against the work to be machined. The amount of eccentricity on the pin is 1.5 mm. giving a three mm. movement to allow for easy loading of the components.

To prevent the operator from turning the clamping bolts in the wrong direction and consequently upsetting the clamping distance, a small pin *C* is provided which limits the movement of the bolt.

Deep Slot Milling Fixture.

(Fig. 4).

I am showing this fixture because on the surface it seems to be an example of what not to do in design. There are loose pieces and several clamps to manipulate and I should have preferred to pass it over but for the fact that the machine shop has acclaimed this fixture on one or two occasions. They state they have had neither trouble nor scrap from it, whereas the type of operation on which it is used had previously given difficulty. Anyway, I am showing the design for what you may think it worth—it may be found useful. It is for milling deep and narrow slots, and this deep slot milling, you will realise, is quite a nasty little operation.

The circular bosses on the component are first straddle milled and drilled. The components are then assembled three together on each of the two pins (shown at *A*) which fit the drilled holes

and these are placed in the fixture from either end. The holes are thus located in line. The walls of the components are lined up by a parallel motion obtained by two plates (shown at *B*) on the top of the fixture which operate through a pinion engaging with rack teeth cut in these plates.

The components, which are machined on the edges, are then clamped end-wise, and the block *D* locating the pin is clamped to the base.

Two fixtures operate side by side, and in spite of the apparent large amount of spannering to be done, the fixtures are in practice quickly loaded, and, because of the depth of cut, the proportion of loading time to cutting time is quite small.

Slitting Fixture with Mechanical Indexing.

(Fig. 5).

This fixture is used for splitting bushes in halves. Four at once are located on this angle plate fixture, which is bolted across the table of a horizontal milling machine. Four saws, correctly spaced, are mounted on the arbor and after a cut has been taken through one side of the bushes they can be indexed to the opposite side and the operation completed.

The spigots holding the bushes can be indexed by altering the position of the lever *A* which moves the rack *B* sufficiently to turn the gears *C* at the back of the spigot, approximately 180°.

In order that the accuracy of the splitting is not affected by wear or back-lash in the gears, we have arranged that the first slot is accurately located through the bars *D* beneath the spigots. The locating pin is held into the first saw cut by the springs *E* and whilst milling the first saw cut, if there is no previously drilled hole in the bushes for location, the locating pin can be lowered by moving the knob handle *F*. This knob is connected to two pairs of gears, one pair at either end of the fixture at *G*.

Eccentric pins *H* are driven in the upper gears and over these the rod *J* is fitted which presses all four of the locating levers down at one time. This is also brought into operation whilst indexing.

The fixture was designed to be used for concentric bushes and also for bushes bored eccentrically, hence the necessity for accurate location before and during splitting.

Drill Jig for Heavy Component.

(Fig. 6).

Twenty-four holes have to be drilled in the side of this component, which is too heavy to be lifted directly into its position in the drill jig. We had, therefore, to make an arrangement to assist in the handling of this piece, which is 3-ft. 6-ins. long. The component is lifted from the floor by an air hoist and is dropped on to skates

which run on two rails beneath the jig. The section shown occurs at two positions along the jig.

So that the component can be adjusted to approximately its correct height for the machined bores to engage with the locating spigots, compensating rockers on the skates are set slightly on the low side, so that when clamping, the component is lifted off the rocker by the tapers on the locating plugs. The component can thus be easily run under the drill bushes and over the clamping bolts which are attached to the pistons of air cylinders. The hinged slotted washer is then slipped under the bolt heads and clamping is done simultaneously at both ends by operating the air valve. The action of clamping lifts the wheels of the skates off the rails by raising the skate body one half mm. on to hardened plates, thus providing support and positive height location for the component.

To remove the component from the locating plugs in the jig, a shoulder is arranged at *A* along the clamping bar, which upon reversing the air valve, forces the component from the locating plugs, thus relieving the operator of the fatigue of the manipulation which might otherwise be required.

I am of the opinion that automatic ejection and the advantages to be gained therefrom should be studied far more that it is by jig and tool designers. It often takes longer to remove a component from a jig than to machine it.

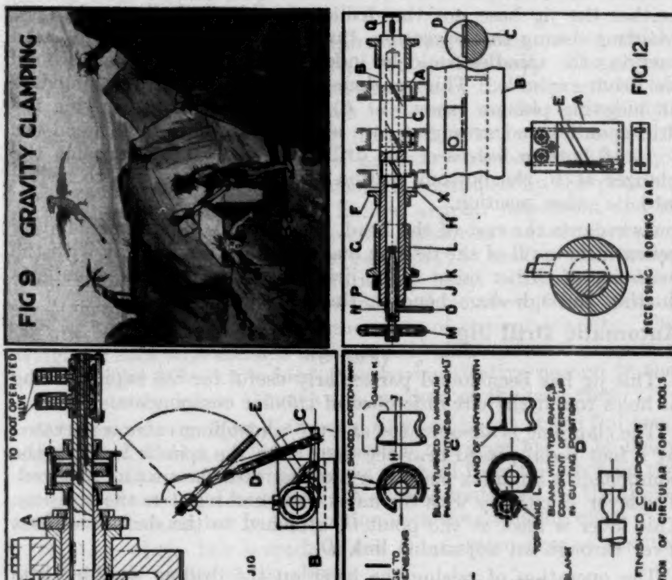
I once had a Belgian working for me in a jig and tool office, strangely enough, and he showed me a fixture which he had designed, using this principle. It was for cutting a slot in the top of aero engine valve tappets. It was merely a split cast iron pot with a coil spring at the bottom and he described it in somewhat these words: "You push him in and compress ze spring. You clamp him up and you make ze cut. Zen undo ze nut and catch him in ze hat," but I do not advocate such rapid ejection as this; the shop floor might become quickly cluttered up, more especially if the operators were not dexterous with their head gear.

Swivelling Three-Spindle Drill Head.

(Fig. 7).

This head was designed for drilling three holes equally spaced on a pitch circle at either end of the component. The component and jig together were too heavy to be turned over by hand. The jig was therefore arranged on trunnions so that after one side had been drilled the jig plates and the component could be swung over to the opposite end and the operation repeated.

Now swinging through 180° would bring the three holes into a position opposite to the orginal setting, as shown in the diagram at *A*. This could be overcome by twisting the whole jig round, but as I have explained, it was too heavy to make this an easy



SWELLING 3-SPINDLE DRILL HEAD FIC7

AUTOMATIC DRILL JIG FIG 8

FIG 9 GRAVITY CLAMPING

FORM TURNING HEAD FIG 10

FIG 11 THE GENERATION OF CIRCULAR FORM TOOLS

RECESSING BORING BAR FIG 12

operation especially as it would again have to be accurately located beneath the multiple drill head. We arranged, therefore, so that neither the jig base nor the drilling machine spindle would need resetting during this operation, that the casting on the drill head carrying the spindles could be indexed the correct amount around the driving spindle. This was done by casting a lug to accommodate an indexing plunger (shown at *B*) on to the casting carrying the drill spindles and arranging two slots in the plate *C* between the top and bottom halves of the drill head, so that on releasing the plunger at *B*, the bottom portion of the head was free to swivel into its other position.

As regards the rest of the head, the thrust is taken immediately beneath the quill of the drilling machine, thus doing away with the necessity of thrust races. The drive from the machine spindle is floating through dogs beneath the morse taper shank.

Automatic Drill Jig.

(FIG. 8).

This jig has been found particularly useful for the rapid drilling of holes round the circumference of tubular components.

The clamping is air-operated and the controlling valve is operated by a foot pedal placed near the floor. On the spindle locating the component is an index plate *A* coinciding with the spacing required. The lever *B* engages with the index plate and registers the position. This lever is also, at the point *C*, attached to the drill press feed lever through an adjustable link *D*.

The operation of raising the lever on the drilling machine lifts the lever *B* and the pawl *E* is raised, consequently revolving the index plate sufficiently to allow the lever to register the next position. Thus the indexing becomes automatic. The link between the two levers is spring loaded, thereby compensating and loading the locating lever *B*.

Gravity Clamping.

(FIG. 9).

I have now shown you a hydraulically operated fixture—the one in which the beeswax was used—and also a few air-operated devices.

I have been unable to cull from my experience one in which gravity alone is used as the clamping medium, but by way of an interlude, I offer you the following, at the same time reminding you that " There is nothing new under the sun." - - - - - - - - - - The cause of the trouble is in the cave.

Form Turning Head.

(FIG. 10).

This head is designed to be used on a standard bar lathe (for

taper or form turning long, slender shafts) and is somewhat similar in construction to a die head.

The body is slotted to house three sliding blocks, two of which are fitted with rollers and one with the cutting tool. The points nearest to the centre on the circumference of the rollers must be maintained the same distance from the centre as the cutting edge of the tool. The tool, after every re-grind, is set with a gauge to maintain this dimension. This is necessary for centre cutting.

The radial movement of the blocks is controlled by the position of the cam ring *A* which has a limited angular movement and is spring loaded in one direction in such a manner as to cause the roller in the bracket *B*, mounted on the periphery, to bear on the former in the shoe *C* mounted on the stationary body. The flat section bar *D*, is anchored to the head of the machine above the work and has one edge formed to the requirements of the component. The straight or back edge slides in the stationary shoe and on the opposite side the roller follows the form transferring relative motion to the tool and steady rollers through the medium of the cam ring.

By operating the lever *E* the cam ring can be set at the full open position and locked. This is required if the start has to be made over a shoulder and for withdrawing the tool from the work on the return stroke. The diameter of the work is controlled by the thickness of the forming bar in conjunction with the adjusting screw *F*.

The bore of the box is made as free from obstruction as possible to allow easy egress of the chips.

The Generation of Circular Form Tools.

(Fig. 11).

The correction of circular form tools on which the cutting edge is offset from the centre of the tool to make front rake has provided enthusiasts with plenty of opportunity for exercising their skill and much has been written on the subject.

When the form is composed of straight lines, the amount for correction can be easily obtained by mathematics. But when curves occur, I would suggest that the following method of generating a ball forming tool is worthy of consideration.

It is necessary that a master gauge as shown at *A*, to component dimensions be made. This presents no difficulty.

Next turn a white metal blank, *B*, approximately the diameter of the finished tool and cut the blank away an amount representing the chip clearance on the tool. Across this blank through the line *F.G.* shape the finished form, shutting out daylight to the master gauge, and, resetting the blank in the lathe, turn until a bare witness of the previous shaping remains along the line *H.J.* (shown at *C*).

Now machine the blank until one-half only remains, and make a gauge *K* to the profile when the half blank is lying on its flat surface. The gauge is then the master for a form tool not corrected for top rake. A tool made to this gauge, and the same diameter as the white metal blank, should now give perfect form, and although there is no top rake it can be used satisfactorily in the third or fourth position on a four-spindle automatic for a final scrape for correcting errors on the previous roughing tools.

Should it be required, however, that the final tool has top rake, then before machining the blank to obtain the half as previously described, cut the top rake, *L*, in the white metal blank.

Then offer up to it at the same setting as on the production machine (shown at *D*) a correct component *E*. This may be set up on a milling machine with the blank in a vice and the component mounted in a chuck or on the mandrel. Then allow the component to rotate rubbing on the white metal blank until a "land" is produced throughout the length of the form. The blank can then be returned to a lathe and machined until a thin line of witness is left, to which a gauge is made in a manner similar to that required for the tool without top rake. Accurate spheres have been produced by tools generated in this way.

Recessing Boring Bar.

(FIG. 12).

There are four recesses in the bore of this component which have to be machined to very close limits, not only with regard to their relative distance one with another, but also from the finished face of the component at *X*. The diameters also of the recesses have to be very accurate. The arrangement shown has satisfactorily simplified what would otherwise be a difficult and costly operation.

The strip tools for forming the recesses are held in holders shown at *A* which are a good sliding fit in a slot cut in the tube *B*. The bar *C* is "DEE" shaped and across the face the keys *D* are left standing, which fit into keyways *E* in the tool blocks.

To keep the tools in the correct relative position to the machined face of the component, the "U" shaped slip collar at *F* is dropped over the bar against the shoulder at *G* and a bar gauge *H* inserted between the face of the collar and the work. From this setting the locknuts *J* and *K* are adjusted against the bush *L* in the boring jig.

The bar operating the tool blocks is fed by the hand wheel and screw *M* operating in the nut *N* which cannot revolve, it being anchored to the jig by the arm *O*. The depth of the grooves is controlled by previously setting the locknuts *J* and *K* which limit the travel of the screw.

The end of the nut P in the bore of the bar prevents the key from being wound past the end of the slot in the tool block, and thus allowing the tools to fall out of the bar, the nut itself being anchored by a split washer in a groove against the arm. The bar is attached to the machine spindle and driven by the end Q.

Boring Jig for Long Interrupted Bore.

(Fig. 13).

The bore through this component is approximately 3-ft. 6-ins. long and 2¼-ins. diameter.

You will notice that in addition to the main bores which have to be machined, there are a number of webs, in this instance, used as oil weirs, which must also be machined. The result is that there is no space available to arrange steadies on the bar in conformity with normal practice.

It was therefore arranged that the boring bars should pull four fluted roughing and finishing tools throughout the length of the hole and also close behind the tools a quill which friction prevents from rotating and is a good fit in the hole being bored. This quill follows along behind the tool for the whole of the length of the operation. The roughing and finishing is done simultaneously on two components placed side by side, one being roughed and the other finished.

The end of the jig is provided with a rotating member carrying the quills which vary in diameter to suit the roughed and finished diameters. At each traverse of the machine a finished component is exchanged for an unbored one and the quills withdrawn off the bars allowing the cutters to be changed over, the quills indexed half a turn and coupled up to follow their respective bars.

For removing the boring bars when putting on a fresh component, the rotating member is turned until cored holes are opposite the bars, which can then be dismantled.

Boring and Chamfering Bar.

(Fig. 14).

This type of boring bar is very useful for preventing a second operation (particularly on automatic chucking machines). The boss shown being machined is part of a stamping, the operation in this case being to bore and chamfer both sides of the boss, the two faces having been previously milled.

A component is set up one on each of the four faces on the turret or a chucking automatic, and the boring bar is held in the spindle. You will notice that this is the reverse of the usual practice, but by this method loading time is eliminated because work pieces can be loaded and unloaded from one face of the turret whilst boring is taking place on another. It is necessary, therefore, to avoid a

second operation, that a component be finished complete on each turret face.

Now because the bar does not travel but merely revolves, the only movement available for operating the back chamfering tool is the forward and return motion of the turret. The tool producing this has, of course, to finish cutting at the same time as the front tool, exactly at the end of the forward motion on the turret. The machine then trips into fast return whilst these two tools are at the finish of their cut. The problem was, therefore, to get the back chamfering tool away from the work and it was necessary for it to return into the bar at a faster rate than the face it has finished chamfering moves towards it. We could not arrange for the tool to move back before the turret commenced moving because there is no motion available to operate this.

As tool and turret movement synchronised it was arranged that the back of the tool acts as a cam and the tool set at 60° ; as the chamfer being machined is 45° the difference in relative speed prevents the component fouling the tool. To operate this tool a plug *A* is fitted into the end of the bar, into which an adjustable screw is fitted. This adjustable screw meets a hardened pad *B*, in the bore of the turret, and consequently pushes the sliding piece *C*, coupled to the tool, which in its turn pushes the tool forward.

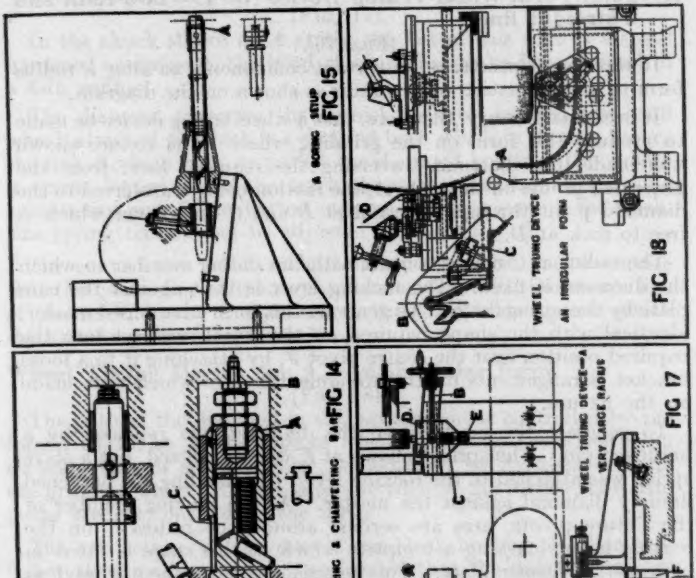
The plate shown on top of the bar at *D* acts as a cover for the previously bored tool hole and as a retaining plate for the sliding member. The springs fitted beneath the shoulder on the tool and in front of the end plug *A* operate simultaneously for returning the tool into the bar.

A Boring Set-up.

(Fig. 15).

This is a useful though simple arrangement for boring two holes in line when the back bore is larger than the one at the mouth of the component and there is no gap in the casting through which the tool cutting the larger diameter can be set in position.

The end of the bar attached to the turret is, therefore, hinged to allow the bar to drop, when being passed through the component, as much as the cored hole will permit, allowing the leading tool for the large bore to pass through the smaller cored hole. The amount of drop is also controlled by a flat on the bar at *A*. When the tapered end of the bar positions itself into the bell-mouthed pilot bush, both tools are brought into correct boring position and remain permanently set for size. Roughing and finishing bars are used and remain permanently fixed in the turret.


A BORING SETUP
FIG 15
BORING & CHAMFERING BAR
FIG 14
BORING JIG FOR LONG INTERRUPTED HOLE
FIG 13
WHEEL TRUING DEVICE
AN IRREGULAR FORM
FIG 18
WHEEL TRUING DEVICE—A
VERY LARGE RADIUS
FIG 17
TWO RAD AND A
STRAIGHT LINE FORM
PROFILE
FIG 16

Irregular Form Wheel Truing Device No. 1.—Two radii and a straight line.

(Fig. 16).

It was found necessary on certain components to alter a radius form to a combination of two radii as shown on the diagram.

It became necessary, therefore, that a wheel truing device be made to produce this form on the grinding wheel. The fixture shown was made, the diamond traversing the required form from the generated profile on the plate *A*, the motion being transferred to the diamond point through the radii at *B* and *C* on a lever which is free to rock at *D*.

The radius at *C* makes contact with the sliding member to which the diamond is fixed. The rocking lever is kept against the cam plate by the springs at *E*. To generate this form a hardened master, identical with the shape required on the wheel, was set into the required position over the centre pivot *F*, by attaching it to a loose bracket, arrangements for the accommodation of which were made on the fixture.

To generate the master cam the diamond was replaced by a hardened pin. The springs shown at *E* were not fitted, but a slave spring was attached to the rocking lever, thus holding the hardened dummy diamond against the master. As the moving member of the fixture pivots, arcs are scribed around the radius *C* on the rocking lever, marking a template which at this stage is fitted in place of the former plate. This template is subsequently used as a gauge for making the former plate.

The grinding wheel being 8-ins. wide, it is, you will realise, an advantage to be able to true the face of the grinding wheel with this fixture as well as the form, so that they coincide without leaving a ridge. It was, therefore, impossible for us to arrange for the movement on our diamond to be operated from a position immediately in line with the diamond point, because this would place the former plate in such a position as to foul the wheel when truing across the wide face.

It is also of advantage to operate through a lever because any error in the former plate is reduced through the ratio of the lever.

A stop is fixed to prevent the diamond entering the side of the wheel on the one side, and after the forming of the radii is completed, the diamond is locked in position by a latch and so becomes fixed whilst facing the wheel diameter. The diamond is set in its relative position by a gauge used on the adjacent face of the pivoting member.

All the small steel parts are made from stainless steel and the pivoted member of bronze and the whole arrangement is covered in, as far as possible, by the casting *H*.

Wheel Truing Device No. 2.—Very large radius.
(Fig. 17).

In the chuck shown at *A* at the top left of this slide is a small hardened component, the head of which has to be form ground to a 6-ft. radius.

The diamond traverses the correct path by turning the hand wheel, attached to which is a screwed bush which in its turn moves the link *B* which pulls or pushes the diamond holder. This holder is spring loaded on to the track through the spring *C* operating against two pins *D*, the flatted surfaces on which seat on the track. The spring tension can be adjusted by the screw *E*.

For convenience when re-diamonding the wheel and to ensure that the centre line of the radius is coincident with the centre line of the work, a stop *F* is bolted to the wheel slide against which the attachment can be located.

Wheel Truing Device No. 3.—An irregular form.
(Fig. 18).

The path of the diamond in this attachment is controlled by the former shown at *A*, the edge of which nearest to the wheel is an accurate though enlarged form, necessitated by its distance from the grinding wheel. On the opposite edge of the former, two cam paths are cut, one above the other.

The two rollers, on the rear of the block holding the diamond, follow these paths which are so formed that the diamond is kept at right angles to the wheel at each position of its cutting, ensuring that the same point on the diamond is being used throughout the whole of the operation. The diamond is held in a sleeve at the back of which a roller is fitted. This runs against the accurate form.

In order to overcome any error in coincidence between these three cams and rollers, compensation is arranged between the sleeve holding the diamond, and the block carrying the sleeve and rollers, by the two coil springs, shown in the plan view, which thrust the roller on the diamond holder against the accurate former and operate in the opposite direction on the other two rollers, so holding them on the cam tracks. The arrangement is operated by turning the handle upon the fixture, rotating the gears, the sprocket wheel beneath which travels along the pins in the face of the former after the manner of a chain. A feature of the rest of the attachment is the two slides at right angles to each other, which automatically compensate and allow the diamond holder to traverse the correct form. For quickness of operation, it is arranged that the bracket *B* remains permanently set on the machine and the rest of the mechanism, being of light construction, it can easily be set in position and removed by the clamps *C*.

All slides remain covered and a guard *D* is fitted to keep water away from the parts.

Small Air Chuck.

(Fig. 19).

This little air chuck was designed for a grinding operation on the collar of a shaft, the time for which was only a few seconds, and it was therefore necessary that loading and unloading should take place in a minimum of time, and the work loaded without stopping the machine. The component being a swaged piece varied in length. The chuck had therefore to accommodate this when location had been taken on a fixed centre at the opposite end of the work. The chuck, as you see, is self-contained, the operating cylinder moving in the body of the chuck itself.

The work, which has one end only centred, is inserted into the chuck with the jaws open, the other end held on to the tail stock centre. The action, on the close of the jaws, provides sufficient forward motion to ensure that the work is "home" on the centre.

Air is induced through the taper shank *A* and thence from the annular groove *B* in the inside bush into the cylinder, pushing the piston forward and closing the three jaws through the medium of the taper ground on the inside of the chuck nose. The reverse motion is obtained through three springs *C* which exhaust the air through the valve.

The chuck jaws are kept open, ready for the component to be inserted, by the taper shoulder which can be seen at *D* beneath the jaws and half-way along their length. The pin *E* screwed into the gland nut holding the brass bush in place is for driving purposes.

The bore in the chamber is 4-ins. diameter and the exposed area at 80 lbs. per square inch exerts a thrust of 880 lbs. between the three jaws. The jaws develop pressure on the work through mechanical advantage equal to 3¼ times this figure, less friction, which in this unit is obviously low.

Combined Spring and Air-Operated Internal Chuck.

(Fig. 20).

This arrangement of an air-operated internal chuck has several interesting features. It was required that the spindle should run at 1,000 r.p.m. and for that reason we set out to design this so that the air cylinder and its mechanism should not revolve, thereby eliminating possible troubles with inertia and the air distributor gland. No part of the cylinder therefore revolves with the spindle of the machine, but is suspended from the bracket *A*, and the two pins *B*, outside the rear bearing of the machine spindle. The air cylinder is used in this instance for opening the chuck and freeing the work and the gripping of the chuck is brought about by a heavy coil spring.

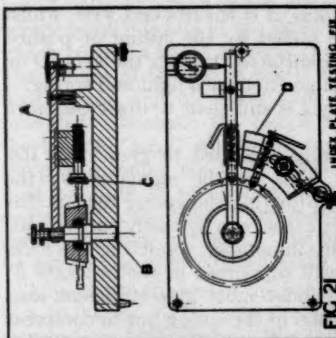


FIG 21 INDEX PLATE TESTING FIX

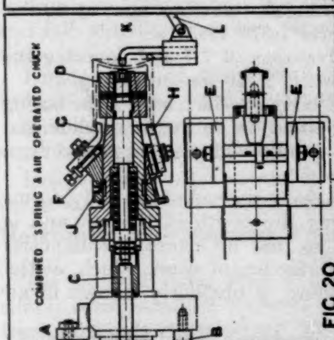


FIG 20 COMBINED SPRING & AIR OPERATED CHUCK

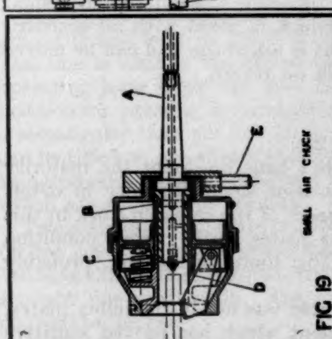


FIG 19 SMALL AIR CHUCK

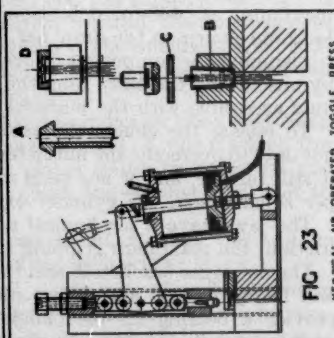


FIG 23 VERTICAL AIR OPERATED TOGGLE PRESS

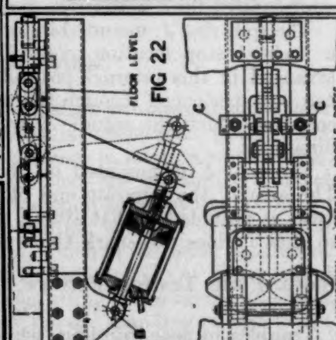


FIG 22 HORIZONTAL AIR OPERATED TOGGLE PRESS

There is no immediate connection between the piston rod *C* and the rest of the mechanism only insofar as it thrusts end-wise, whilst opening the chuck. The jaws are pulled by the spring or pushed by the air cylinder against inclined surfaces through the shoe *D* on the draw bar, the jaws being held in position by a light coil spring.

The movement in closing the chuck is sufficient to draw the work up against the location stop.

On assembling the unit, the spring is loaded to give 1,020 lbs. maximum at .460-in. deflection. This can be regulated by the locknuts shown on the draw bar. Adjusting the spring tension due to changing the component or other cause, can be easily carried out, by unscrewing the body from the machine nose, rendering the locknuts accessible with the mandrel still supported in the brackets *E*.

To release the chuck, the air cylinder must give sufficient load not only to overcome the initial tension in the spring but to compress it still further, and it has been arranged, therefore, that at 80 lbs. per square inch, the cylinder exerts 1,570 lbs.

The jaws have a mechanical advantage of 7.7 and ignoring the friction, the maximum gripping load is 3,740 lbs. on each jaw.

The outrigger brackets *E* and the body *F*, which carries the boring and facing tools *G* and *H* are mounted on an auxiliary slide and provide a bearing for the chuck spindle which is supported in a white metal liner within the body.

The split ring *J*, mounted in a recess at the end of the body, forms a positive stop location, controlling the depth of the cut and is arranged in this internal position so that no errors or difficulties can be experienced through the interference of swarf, which, at the speed at which the spindle is running, is obviously thrown in all directions.

The tool *K* is mounted on the machine's standard cross slide. The arm *L*, the opposite end of which is fitted with an eccentric bush, is provided so that after a cut is taken the tool can be moved so that it does not mark the work on return.

Index Plate Testing Fixture.

(Fig. 21).

Troubles in gear grinding, which I have no doubt the majority of you experience periodically, present some difficulty in determining the exact cause, and one aspect of the research work in this connection is to be sure that index plates are in perfect condition and have not worn beyond allowable limits of spacing, probably not more than .0002-in.

To satisfy ourselves that the trouble was not in the index plates, we devised this measuring instrument which has proved sensitive enough to determine whether the index plates were satisfactory or otherwise.

The index plate is mounted on a special selected ball race and the bar *A* seats on a ball-ended pin at one end on the extension of the centre spindle *B* and at the other end between a pair of ground jaws which permit a small amount of movement, approximately .010-in. The weight of the bar is taken between these jaws on a ball-ended floating pin and at either end of the bar hardened seatings are provided. Beneath the bar is fixed a fork end plunger carrying the locating pin *C* which is a replica of the conditions existing on the gear grinding machine. This fork end has sufficient amount of float to allow it to assume the correct vertical position when in contact with the slots in the index plate. The quadrant bracket *D* carries a similar fork end. The bracket itself is adjustable, and can be set to the approximate pitch required.

Adjacent to the end of the bar is fixed an indicator clock measuring in 1/10,000ths. The ratio at this point being 3 : 1, one mark on the clock gives 1/30,000ths. We then plot a graph showing the rise and fall, starting from zero, as we check the spacing from slot to slot.

The top face of the casting is machined, so that this can be brought to perfect level by means of the jack screws below.

This instrument, we have proved, needs very clean atmospheric conditions for successful working and is stored in an air-tight case.

I might add we have found it particularly useful in proving that our troubles were not in our index plates.

Horizontal Air-Operated Toggle Press.
(Fig. 22).

The next two slides, Figs. 22 and 23, show two uses to which very simply constructed air operated presses have been put. A feature of these presses is the relatively high pressure in relation to their size.

The toggle principle used ensures that the pressure is applied gradually and is at its greatest on the completion of the operation. This one is used in the horizontal position with the cylinders and operating lever below the floor level, which is the most convenient position for pressing a corrugation in the four sides at either end of a rectangular tank six feet long. No lifting is required. The tank can be tilted on one edge and so over the die, standing on end whilst being pressed. The bead formed is used as a buttress for end plates which are soldered in position.

Two air cylinders operate the press and both cylinders are mounted on one head into the centre of which the fork end pin *A* is screwed. We thus eliminate side thrust, triangular lines of force bringing about straight line movement. The cylinders pivot on hinged bolts *B* coupled to the base.

Air for the closing stroke of the press is induced at the top of the cylinder through a $\frac{3}{32}$-in. hole to avoid too rapid downstroke. The

return stroke is operated from the opposite end of the cylinder, the air entering through a larger bore, increasing the speed to save time. The centre line positions for the lever are maintained by a pin which rides in the blocks *C* on either side of the frame.

At 80 lbs. pressure per square inch, the two 5-in. cylinders develop a thrust of 3,000 lbs. and with the toggles at 11° 30-min. from the closed position a mechanical advantage of $7\frac{1}{3}$ to 1 is obtained, the press at this point applying approximately 10 tons. With the toggles at 3° from the closed position, the mechanical advantage obtained is 28 to 1, or approximately 38 tons, and the importance of the above figures becomes manifest when the indentation required is of a deep nature.

It is, therefore, essential to ascertain that there is sufficient pressure available to overcome the resistance of the material at the commencement of the pressing operation.

Vertical Air-Operated Toggle Press.

(Fig. 23).

This example is similar in construction to the previous one, except that there is only one operating cylinder instead of two, and is used in a vertical position for pressing up the ends of steel tubing so as to form an adequate seating for an oil pipe union nut. The form is shown enlarged at *A* on the slide.

We determined that pressure not less that 15 tons would be required and the press was arranged, therefore, to give this figure with the toggles approximately 3° from the vertical position.

The tubes are held in a collet *B* and a downward stroke of the press—with a washer *C* over the tubing—closes the collet on to the tube and a second stroke of the press—with the washer removed—up-ends the tube itself. For ejecting the tube from the collet, the register plate is indexed to a second position by a lever alongside the collet arrangement and a third stroke of the press forces the outer ring off the collet so freeing the tubing. This is done by the aid of the collar shown at *D*.

Profile Turning Lathe.

(Fig. 24).

This machine was developed for profile turning long high tensile shafts, having two distinct tapers several diameters and in one position a collar. The shaft is held between centres and driven at the one end by a floating, self-gripping and releasing driver. The tailstock is fitted with a specially designed, heavy duty running centre.

The weight and length of the shaft is such as to require two men to place it in the centres without the assistance given by the arms fitted on either centre, which facilitate lowering into correct relative position from an air hoist. The shaft is easily placed in the V's at the


Fig 24
A

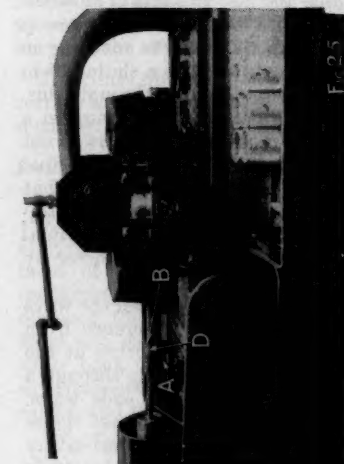


Fig 25
A
B
D


Fig 26


Fig 27

bottom of these arms by the guides which are bolted to the roller steady brackets and can be seen at *A*. These also prevent the shaft damaging either the tools or parts of the roller steady mechanism.

Two saddles are fitted to the machine and also two sets of steadies. The movement of the cross slide during its longitudinal traverse is controlled by a former fitted between the ways of the machine in conjunction with a roller attached to a block which is a sliding fit in the saddle block. The cross traverse screw passes through this. The roller maintains contact with the former by air pressure in a cylinder attached to the cross slide. The cross traverse screw is not used except for setting the tools in the first instance and for the final operation of facing down the sides of the collar on the shaft, but that during the longitudinal traverse it forms a link between the top slide and the roller block. The tools are set to the correct longitudinal spacing by gauges off the side of the top slide and for diameter by index marks on the serrated hand wheel.

In spite of the fact that the roller and former are between the ways of the machine in such a position as to expect interference from swarf, this central position was chosen rather than another at the rear of the machine to avoid any locking of the cross slide through a couple caused by forces outside the limitations of the slide ways. Shoots are provided beneath the former and roller for the easy egress of the swarf. Swarf troubles have not been experienced ; but in any case, the arrangement is such that in the event of swarf getting between the roller and the former an oversize ridge would be formed, which is easier to remove than accommodating a groove with a putting on tool.

The square turret is fixed to the slide, so that after the profile turning is finished the box can be indexed and the faces and radii at either side of the collar finished, using the slide in the normal manner but with the air pressure released.

Perhaps the most useful feature of this machine is that of the roller steadies. These operate in what appears to be rather an enormous bracket, which of necessity has to be built out at the rear of the machine to provide clearance for the air cylinders attached to the saddles. This bracket is of heavy construction to assist in damping out vibration and make possible the use of sintered cutting materials. Two pairs of rollers operate in each bracket ; one pair is locked on diameters which have already been turned on the machine. It is not necessary that these be turned to a definite size, as each pair of rollers is so arranged that they can be brought on to any diameter within the range allocated, with equal pressure on each roller and then locked in position, the whole operation with one movement of a lever.

The cut on the two saddles is then started and after the tools have passed the first pair of rollers, which have not yet been brought into

use, they are brought down on to the shaft, locked in position, and the pair which were previously set on the shaft are released and returned clear of the work by a reverse motion of the lever. Although these steadies are self-setting and almost automatic, the pressure applied is so uniform that no mark is left in the shaft between the changing of the rollers.

The times obtained on this machine are less than those quoted by certain multi-tool lathe manufacturers, who also recommend several separate set-ups to complete the shaft.

Boring Set Up on Potter Auto.

(FIG. 25).

This is rather an unusual set up for boring two holes in line in a light alloy casting. A jig holding the components is clamped to each of the four faces of the turret which indexes after the completion of the machining on one component, thereby leaving a loading station and allowing the machine to run continuously. A boring bar piloted front and back in the fixture, is fixed into the machine spindle by a draw back collet and is arranged to run at 1,400 r.p.m., the feed approximately .003-in. White metal bearings are fitted with large oilers, and the spindle is driven direct from the countershaft.

The feed cams operating the turret have been arranged so that after one hole is bored the turret accelerates across the gap, to save time, before boring the second hole. The turret advances through the medium of the quick feed motion and travels over the boring bar, tripping over into the slower feed before the tool touches the work.

The cross slide operating cams have been redesigned to bring the hinged and spring loaded bar shown at *A* behind the bush, at the correct moment, thereby holding the bush whilst the jig slides over into the correct relative position. This bar is spring loaded so that in the event of anything going wrong with the mechanism and it strikes the bush broadside, it becomes deflected instead of causing damage.

The spring loaded plunger shown in the front of the fixture holds the bush in place and prevents it from turning by a flat between the shoulders on the bush.

The cross slide now moves out of the way and the turret, after completing the boring operation, recedes, and the bush is extracted from the fixture by the collar shown at *B*, the bush at the same time being prevented from riding along the bar towards the spindle by a spring loaded ball, which is situated in the bar at *D*.

Lubricant is fed to the front of the cutting tool through the turret of the machine, through the bush and along the hole in the centre of the bar.

Flather Conversion.

(Fig. 26).

This is an example of one of a whole battery of very old Flather gear cutting machines, which were converted to various special purposes. This machine is arranged for automatically drilling and reaming holes in a circle. The holes on the components are too close together to allow for multiple drilling. The machine is provided with a change gear head to allow for a range of speeds.

The bush plate, in the instance described, carries two bushes, one for drilling and the other for reaming. It is spring loaded and remains against the work, allowing the head to feed forward. The drill plate is held in its correct relative position by two guide plates, one on either side of its rectangular shape. After the drilling is completed, if the holes require reaming, then the plate is indexed round to its opposite position. The hook fitted at the side pulls the bush plate away from the work on the reverse motion.

Owing to the weight of this head being much greater than the saddle originally on the machine, we replaced the lead screw with a new one of half the pitch. The lead screw nut is spring loaded to absorb the extra inertia load on the quick return stroke.

Horizontal Multi Drill.

(Fig. 27.)

This example shows the conversion of an obsolete bar lathe—taken from the scrap bay—and converted into a 14 spindle horizontal drilling machine for drilling holes in the flanges of various tubular members which are too long to be accommodated beneath a vertical machine without digging a pit.

The machine is motor driven, the motor being mounted upon the drill frame and is driving by chain from the change speed gears, the ratio of which can be varied to provide the drill speed required. The change feed box is driven by a belt from one of the gear spindles. The machine's standard gear box is retained, but the whole of the saddle operating mechanism is new, including the rack and pinion which has now been placed between the ways of the machine, and provision made to protect it from the drill swarf.

To prevent the operator damaging himself on the drills whilst loading components on to the table, the machine is arranged so that when the table is wound off the drills, the motor is automatically tripped through an Igranic switch. For starting up the machine a push button is used. For quite a low cost we have now a first class production machine.

Conclusion.

Now as a machine tool is only making profit whilst the tools are actually cutting metal, it is of interest to tour a works, and, knowing the number of machines installed, put a mark on a piece of paper

representing each machine actually cutting as you pass it. Those of you who have not already done this would, I think, be astonished at the very low percentage of machines making chips.

It should, therefore, be the aim of the tool designer to arrange that loading times are as short as possible, and where possible to arrange that loading can take place on one batch of components whilst another is being machined. The amount of money which can be spent towards the reduction of idle time is, of course, regulated by quantities, and the work of the designer is controlled in proportion.

Ensure that jigs and fixtures are rigid enough. The possibilities on some jobs are never realised through this fault.

Remember also to allow plenty of clearance between the jig and the component. Although we may be tooling castings definitely dimensioned, variation may occur when they arrive in the works in quantities. Similarly, jig castings may likewise differ from the drawing dimensions.

Quite a large proportion of the jigs which can be seen in any works are so many swarf traps and it is surprising the amount of time which has to be wasted by operators in cleaning. Make sure also that locating points are clearly defined and are not such as to be likely to hold swarf swept from adjacent positions.

Do not expect operators to be jugglers. Arrange that the component can be easily loaded into the jig. On heavy components give the operator an opportunity of sliding his component into the fixture. Do not put him in the position of having to " wangle " it in by hook or by crook, perhaps juggling with an air hoist at the same time. Consider the effort required and design to reduce it.

In the case of jigs where there are sighting faces, give the operator an opportunity of being able to see the faces easily without ricking his neck. Put the jig on trunnions.

A useful wrinkle on subsequent operation jigs, particularly on heavy components, is not to allow locating pins to stand proud, but rather that they are disappearing, and can be raised into position after the component is roughly located in its place, against adjustable screws or other means.

Make sure also that adequate arrangements are made for the supply of coolant to the cutting edges, so that at the same time as the cutters are cooled the swarf is swept clear. This should be watched far more than it is, particularly on multi drill jigs. It is no uncommon sight to see machine operators augmenting the flow of cutting compound when they could be more profitably occupied in preparing the next component. Another point often overlooked on milling fixtures is providing for the adequate control of the cutting compound. Arrange where possible, that the base forms a sump big enough to prevent the swarf flowing over the machine table and on to the floor.

Before I finish may I say a word or two about the tolerances to which jigs can be made commercially.

I have seen many jig drawings submitted to manufacturers calling for much closer tolerances than were actually required, in some cases even down to .0001-in. when tolerances of several thousandths would be equally satisfactory on the work to be machined. Closer tolerances can, of course, be obtained with the greatest care and manipulation, but extreme accuracy is costly. Give the man who has to do the estimating the opportunity to ascertain the economic value of a jig, otherwise you may pay too highly or be disappointed upon delivery.

It is with regret that I close this paper without being able to make any recommendation towards that philosopher's stone, the elastic jig, which accommodates subsequent design alterations.

My thanks are due to the management of the Associated Equipment Company, who have given me permission to write this paper, and I know their attitude in this connection is much appreciated by the Institution.

Discussion.

Mr. Halliwell: First of all I should like to congratulate Mr. Jones on his paper, and also the London Section in having a President who has the interest of the Section sufficiently at heart to open the session by reading a paper himself, and a paper to which he has obviously given a lot of time and thought. He has shown us a very comprehensive range of examples all of which present interesting features, and he is careful to tell us that they have all proved successful in practice, including, I suppose, the gravity clamp shown in Fig. 9. I think in this case he might give us the ratio of loading time to cutting time.

The first example which he showed us, the beeswax compensating fixtures, illustrated in Fig. 1, interested me very much. I should like to know whether he could give us any relative comparison of costs between a fixture of that type as against the type of fixture which it superseded. Also, has he tried any other medium than beeswax in a fixture of that type, and, if so, with what sort of results? What sort of fit did he find necessary in practice for the plungers in the holes? Can the cut where necessary be taken against the beeswax, or is it necessary to provide a solid backing always for the cut? In the particular fixture shown I wondered whether in practice the top clamp had to be released to unload, or whether just one turn of the clamping screw operating through the beeswax was sufficient to enable the work to be taken out.

Another interesting point arises when considering the clamping loads which could be applied by the system illustrated and that is that Mr. Jones presumably found it desirable to arrive at some basis for calculating the size of his screws and plungers in order to be sure that sufficient pressure could be applied to hold the work, and conversely that too much pressure could not be applied. Did he work on a basis of known or assumed desirable pressure on the work itself, or did he attempt to approximate to the pressures which would have been given by a normal clamping device of orthodox style? In this connection the table he has given us of loads transmitted by various diameter screws turned by wrenches of different lengths is very interesting, but also rather bewildering. One would expect that other conditions being equal a B.S.F. thread would transmit more load than a Whitworth thread, and this is borne out in the main by the table. But why should $\frac{1}{4}$-in. or $\frac{5}{16}$-in. or $\frac{3}{4}$-in. B.S.F. bolt show a much greater advantage over Whitworth than a $\frac{3}{8}$-in. or $\frac{5}{8}$-in. B.S.F. bolt, or a $\frac{7}{8}$-in. B.S.F. bolt show no difference at all from Whitworth?

The automatic timing and clamping milling fixture which he showed in Fig. 2 seemed to embody almost every feature which could be considered desirable in that type of fixture, but I should like him to tell us whether the springs shown constituted the only clamps necessary for holding the valves in, and whether this was found sufficient to hold them firmly enough, especially where the tendency of the cutter would be to lift the work out of the slots. He showed us a deep slot milling fixture, but it was not provided with any cutter guides or setting blocks. It would be interesting to know whether he tried these components both with solid and with cored slots, and if so, which he found to be the better.

He makes one or two references to the desirability of quick and easy loading and unloading. In fact, he gives us an example in Fig. 6 of automatic ejection, and although he is apparently not in favour of going as far in this direction as the fixture which he described for cutting slots in the tops of the valve tappets, there are many cases where automatic or semi-automatic feeding and ejection of small components might advantageously be arranged. He also mentions the necessity of not designing a jig which in effect becomes a swarf trap. These are points which should be carefully studied if ordinary machining operations are to be speeded up at all. I might instance that in press tools this point has to be automatically considered, as cutting time is definitely very short and it becomes essential to have automatic feeding and ejection, and also essential to have automatic and quick swarf clearance.

I am surprised to find that Mr. Jones makes no comment at all on the necessity or otherwise of foolproofness. It is obvious that in the majority of his examples this point has been considered, perhaps subconsciously, as in no case does he touch upon it or bring it forward. There is one process which he did not mention at all, which I suppose he would classify as coming under the heading of press tools, but which is so closely connected with ordinary machine shop operations that some reference might have been made to it. I refer to the coining or swaging of boss faces, or similar jobs, in place of milling or other cutting operations. This is a method which I think has been developed to a considerable extent in some shops, and it would have been interesting to have had the author's personal views upon it. Another point which he has not touched upon is the question of standardisation of various jig and fixture components which is practised to a greater or lesser degree probably in every shop in the country, but upon which every designer or executive has slightly different ideas. If it were possible for something approaching a national standard to be drawn up and fixed upon for such things as liner and slip bushes, clamps, tenons, etc., used on everybody's jigs, and stocks of these held available, not only money, but often which is more important,

time, could be saved in lots of cases. One cannot listen to a paper like this, compiled with such care, and containing such a lot of information, without coming to the conclusion that jig and tool design has advanced to a stage where further progress is probably sure, but certainly slow. By this I mean, improvement is gradual and in detail, and this raises the question : " In what direction can any major advance in the technique of tooling be made ? " I know this is a leading question, but I think we should all like to hear from Mr. Jones his opinion on that point.

Mr. Jones : Mr. Halliwell has asked if I can give him figures regarding the cost of the beeswax fixture over the other types. It would, I think, be more expensive, but the fixture was not designed primarily for cost reasons : it was designed to form a type of fixture out of which we could get accurate work at a faster rate. I have not tried any other medium than bees wax, but I should think any of the more solid liquids would do equally well. Regarding the fits of the pins, we made no special effort in this direction. The job was dimemsioned in the ordinary way, calling for Newall "A" linits, and we have had no subsequent trouble. The tool room must have realised that the pins should be a " nice " fit. In connection with the necessity for lifting the top plate for unloading components, it must be realised that the solid nature of the beeswax will not permit of it flowing back when the clamping screw is released. It is necessary, therefore, that the top plate be eased off, so that after a new batch of components is loaded, the tightening down of the top plate forces back the beeswax, through the medium of the pin beneath the component. To obtain the required pressure on each of the components, we designed to get the equivalent of two ⅜-in. bolts, clamped on each piece. In connection with the disparity on the loads transmitted by the various bolts, as shown in the table, I would point out that this was the particular reason for showing the table, so that designers of fixtures of the nature of the beeswax type can have a practical example of the loads likely to be transmitted by the average resulting from individuals of different strength and so take precaution accordingly.

In connection with the query regarding timing and clamping milling fixture shown in Fig. 2, the springs shown were quite adequate for holding the components after a recess had been machined in the fixture to accommodate the heads. Before this recess was made, the springs would not hold the components against up-cut. In connection with the deep slot milling fixture, and the desirability of coring the slots, it was not possible to do this, as the component was a stamping and the shape necessitated it being stamped in the opposite direction. No cutter guides or setting blocks were used on this fixture, the cutter being set centrally between the two plates on top of the fixture. In connection with the

coining process, I am convinced that it is the ideal one for avoiding certain machine shop operations, and whilst I have little experience of it, it is undoubtedly to be recommended for quantity work, especially when stampings have to be finished to very close limits with regard to weight. The normal stamping varies considerably in weight, and much time has to be spent on connecting rods—for instance—after the machining operations, to bring them to equal weights. The coining process obviates this work and also in many instances it does away with the necessity for machining the bosses to width. Enormous pressures are, of course, required.

The standardisation of parts for jigs gives the tool room superintendent an opportunity of showing his chief what a well organised department he has, especially if he takes the trouble to lay them out on shelves in a conspicuous position, but the application of such parts is, in my opinion, strictly limited. If your jigs and fixtures are to be as efficient as possible, each part must be made to suit individual requirements. I have tried on many occasions, even to standardise drill bushes, without success. Nevertheless, as I have rather facetiously mentioned above, they can serve a useful purpose.

I do not quite know what answer to give to the query " In what direction can any major advance in the technique of tooling be made ? " unless it be in avoiding the necessity for jigs and fixtures through either the coining process, hot brass pressings, die casting, and similar processes. With regard to the foolproofing of jigs and fixtures, I made no mention of it in my paper because it is, to my mind, an obvious and necessary precaution and I was surprised that any other opinion existed, but since it has been raised, I should like to read you part of the discussion following Mr. Youngash's paper on " The Human Factor in Industry." " In planning and scheming devices for production, they ought not to forget that in most cases the machines or devices had to be worked by human beings, and those human beings had brains. In designing, they should always consider that the human brain could do more work than was perhaps imagined. Some machines and fixtures were made in such a way that they did not call for any interest on the part of the operators, who ought to be helped and encouraged to think, and so get real benefit from their minds."

If this policy was carried out in the design of jigs and fixtures, it would create a rather unsatisfactory position for the designer, especially if he were called into the machine shop because scrap had resulted from an operator putting the component into the jig either up-side-down, or the wrong way round, especially if he had replied saying, " We can supply you with the jig but we can't supply the brains with which to work it "—because he would lay himself open to the retort obvious—" Perhaps you have none to spare."

MR. TAYLOR: On the question of the advancement of technique, and this also bears directly upon the observations just made, we may look for developments in the multi-station indexing fixture. With this equipment the operator is kept busy all the time the machine is working and he is loading the next component while one component on one side of the indexing fixture is being machined. By this means the operator's attention is continually occupied and the most is made of the machining time of the machine. Is this not a great advance upon the method or device where the machine is standing idle whilst a new component is being put into the fixture? One must have a scale of production to warrant the expense of the multiple station indexing method, but where it is possible I think its employment leads to a great development of the technique of production.

MR. JONES: I am in agreement. But we must not lose sight of that passage in my paper that the reduction of idle time and amount of money which can be spent towards it, is entirely regulated by quantities.

MR. PUCKEY: Criticism of jig and tool design is very difficult because it is rather easy. What I have in mind is that there are usually two ways of doing a job, one probably as efficient as the other, and the result is that you can criticise quite easily and still leave the other man where he was. The first case is the beeswax compensating jig. I do not know whether Mr. Jones brought this jig forward as an illustration of the compensating arrangement or of the particular jig itself and its application, because I should like to find one or two minor faults with the application. In the first case, he realises that he has broken one of the rules of jig and tool design in machining against clamps. He will probably retort by saying that beeswax is practically incompressible, and this is quite true, but I should like to know whether chatter is noticeable. In the second place I would point out that putting the pins on an angle is rather a weak point, because in the triangle of forces, the vertical component is obviously only about 75 per cent. of what it should be, and therefore, placing the pins vertically, forcing directly upwards, would be rather better, although not giving side location. The other point Mr. Jones mentions is that the tolerance on the diameter of the shafts possibly does not give a consistent result in the depth of the slot. I have been casting my mind back over a few years and thinking about shafts and spindles where you require a dimension to be accurate from the top of the component to the bottom of the slot and I have not found one yet. My experience, in a wide range of components, has been that the measurement from the bottom of the component to the bottom of the slot is important. You will not get this consistent accuracy in the application shown.

Fig. 8, the automatic drilling jig. I do not quite see the virtue of using a foot pedal for clamping. This, I should imagine, would

be all right if you were drilling very small components and the operator was sitting down in front of the machine and his foot near the foot pedal, but where you have to move away from the machine, I should think that it would be very much more simple in application and in design to place a small throw-over lever so that it could be operated by hand. Fig. 14, boring and chamfering bar. This is a good idea but its weak point is that there are two springs used for withdrawing the small chamfering bar. The application of the two angles is ingenious, but I should like to know if the spring behind the small chamfering bar ever stuck and with what results to the component. I have developed a bar for such an operation where it is practically fool-proof, and does not depend on the action of the spring to force the tool back. Fig. 15, swinging boring bar. That is an ingenious application, but Mr. Jones will agree that he could extend its application by bringing it into use for the machining of long *parallel* bores. In his particular case he tucks the bar in behind a small bore, brings it up into the pilot bush, and machines a large diameter behind the small bore. This could be quite usefully employed in machining a long parallel bore, getting the traverse time practically divided by two, and decreasing the time for machining.

In Mr. Jones' last paragraph he mentioned the elastic jig. I have nothing to offer in connection with that, except perhaps the one word, anticipation. We all know that now and again certain alterations come through from the design office, and I have grown to be rather a pessimist in these affairs. I have found that the best thing to do is to imagine all sorts of things likely to happen and get to the innermost thoughts of the designers, although it is, of course, difficult at times to appreciate the outermost. I think if one does attempt to delve into things a bit and realise where the trend of design is going, it would be very much more easy for a future generation on the particular jig in question if you fling out a few bosses or thicken up here and there so that you can anticipate the alterations or repairs that are necessary from time to time. To the young jig designers—I do not speak from the pedestal of age, but I have been through teething troubles and know a certain amount about it. I advise you to get down to the fundamental principles of jig design. That is the most important thing and the details will, to a certain extent, take care of themselves. If these young people do not know where to get hold of the fundamental principles, perhaps they would apply to an experienced jig designer or to the Secretary of our Institution who might consider persuading one of our committee to do some work on the subject. When you have got hold of these fundamentals, examine as many existing jigs as you can and apply the principles to these jigs. Do not worry if about 60 per cent. of the principles have been broken—it

will only point out to you that there are more and better fish in the sea than ever came out of it, and although we have had during the past twenty years very considerable advances made in jig and tool design there is still plenty of room in the future for improvement in one of the most interesting and important branches of the Institution of Production Engineers' activities.

MR. JONES: Mr. Puckey has suggested that we are fundamentally wrong in showing a design in which we are machining against the clamp. On the surface it appears that this may be so, but I see no reason whatever why we cannot machine against any part of the fixture providing that it happens to be stiff enough for the purpose. Mr. Puckey has certainly pointed out the possibility of error in the depth of the flat for the beeswax fixture, but this can be taken care of by arranging that the tolerances on the outside diameter of the shafts are such that the depth of the flat can be controlled to drawing limits. It is also suggested that flats on bars are usually measured from the opposite side of the shaft's periphery, but Mr. Puckey's remarks would, I think, have been even more pointed if he had suggested that the flats were measured from the centre of the bar.

Regarding the foot pedal on the automatically operated drill jig, the operator's right hand is on his drill press lever and at the end of the operation the component is in such a position that it can be taken off with the left hand. I would prefer that he pressed the pedal down with his foot and pulled his component off with his left hand, the right remaining on the feed lever so avoiding much unnecessary movement. In connection with the boring and double chamfering bar, it is asked whether the springs have ever stuck—I do not know that they have. The two springs were used because these were the only places available from which we could get assistance to withdraw the tool. Mr. Puckey has suggested that this can be done without springs, but he must obviously have more movement available than only the reverse motion of the turret.

If Mr. Puckey is able to anticipate what the designer will do next, even to a limited extent, I must tell him that he has a far greater imagination than I. One can widen fixtures, thicken up walls, and increase diameters of bosses, anticipating that one day we may, or may not have to make some alteration on the fixture and that this extra metal will then be useful, but obviously the original cost of all your tools will be greater, even if this is calculated from the extra weight of material only. My experiences are, however, that changes in design which take place so frequently nowadays, can rarely be accommodated by the precautions suggested. In connection with Mr. Puckey's suggestion that the importance of jig and tool design warrants the need for a class in the Institution for prospective jig and tool designers, I should like to say that this is

precisely one of the things which we are trying to do this session, and is the reason for the meetings we are holding at the Northampton Polytechnic and elsewhere, in an endeavour to interest youths in our Graduate Examination, in order that they can subsequently form and run their own Graduate Section in the London area. I am sure, that when we bring this about, the Senior Section will be only too glad to give them every help and encouragement.

Mr. Baty : There is only one point that I would like to raise and as it was not in the paper you may rule it out—that is the question of fabricated jigs. One hears a great deal at the present time about the question of built-up jigs where a small number of components have to be machined, and I would like to ask Mr. Jones if he has anything to say on this question of fabricated jigs.

Mr. Jones : Of late years there has been much reference and propaganda for the built-up welded jig. It is no doubt a very convenient method of construction where jigs are wanted quickly and furnaces are available for subsequent normalizing after welding. I do not think there is any possibility of this method of construction completely superseding cast iron, particularly on fixtures requiring rigidity or the faculty of absorbing and damping out vibration. A steel jig is no doubt stronger than iron for a given section, but is a condition permitting greater deflection and allowing permanent set in the event of the fixture being dropped, whereas cast iron would possibly break and avoid future scrap work. For flat irregular-shaped jigs and other fixtures lending themselves to the tube, bar or plate stocked in many works, welded fixtures have advantages. Some people recommend them, some people use them, but one of the largest firms of tool-makers in the Midlands told me that they could get patterns and iron so cheaply that welded fixtures are too expensive by comparison.

Mr. Hixon : I was very interested in the eccentric fixture, Fig. 3, but I was intrigued as I remember several years ago seeing a fixture for castellating nuts made in that way in which the designer had totally forgotten what is termed the approach distance, with the result that when he started to cut his nuts he found half of them kicking up in the air because at the moment of approach it was not fully clamped, and I perhaps did not notice the point on Mr. Jones' illustration, but I wondered if he had found that difficulty, that an eccentric clamping device is only tight at the point of dead centre and is rather less than tight at the distance of approach where the cutter touches the work. I would like to know if the author has noticed whether that is very serious and if it can be overcome readily.

Mr. Jones : I quite appreciate the last speaker's point, but we have not had the trouble he described. This difficulty can be

overcome by careful laying out on the drawing board. At the same time, we may have had a little good fortune on our side.

MR. SPECK: Would Mr. Jones tell me which he recommends, soft or hardened setting pieces for milling fixtures? My two reasons for asking this question are that if you make them hard there is a possible danger of damaging a running cutter, and that if you make them soft, there is a possible danger of machining them down without the operator noticing, and therefore all future setting will be incorrect and create scrap work, etc.

MR. JONES: I would certainly recommend that they be hard and so avoid the possibility of an operator milling the setting pieces to accommodate his scrap, but possibly you do not consider that operators would do such a thing.

MR. GILES: Mr. Halliwell raised an interesting point regarding setting pieces which I do not think was answered. That is when setting pieces should be used. I have found it usual to use setting pieces when components are not inspected between each operation, but when the components are inspected or gauged between each operation the setting pieces are unnecessary, and the cutters are set to the inspection gauge. I do not know whether there is any ruling as to when one should use setting pieces and when not, but I would imagine that that would be the case. Another point about jig design that has always struck me is, that it is more or less an easy matter to design a complicated jig similar to the ones we have seen to-night. I will say it is altogether an easy matter and one that can be got over one way or another. I think that the art in jig design is to be able to design a jig from next to nothing if money is limited, so as to get the most efficient jig under the circumstances. Most of the jigs we have seen and have discussed to-night are jigs which can only be afforded by large concerns and very often if smaller concerns want a jig they cannot afford to pay for it, and it is then when the art of the jig designer is put to the test and he is able to design a jig suitable for the job for practically next to nothing.

MR. JONES: In reply to Mr. Giles' question as to when to use setting pieces or not, it again becomes a question of economics. When the quantities are sufficient, even though the parts will be subsequently viewed, I consider that for the convenience of the operator and quickness, that setting pieces should be supplied. We all of us come up against the problem regarding making jigs cheaper. I have known times when it has been necessary to make a jig for three components only, and the jig must then be made, of course, in the simplest and cheapest possible manner, but if one has quantities to machine, it is as true of jig and tool design as of anything else, providing always that the designer knows his job, that one only obtains value for the money expended.

MR. SANDY: Regarding the beeswax fixture which has caused such concern, I have had experience of using the more "solid liquid" in the form of stauffer grease in a different type of fixture. In this case it was to accommodate diameters with slight tolerances. A number of "V's" were cut in the fixed jaw of a machine vice and in the moving jaw a hole was drilled parallel to the fixed jaw and filled with grease with screw plugs sealing each end. Sliding plungers were fitted into holes bored at right angles, and opposite to the V's in the fixed jaw, thus compensating the varying diameters. I do not wish to detract from the paper when I mention I was using this jig some many years ago in the provinces. Regarding fabricated jigs. It was my unfortunate business at one time to make quite a number of jigs for a firm which insisted upon fabrication. Much may be said for and against. They certainly cause a lot of trouble unless you carefully anneal them to start with, but there are distinct advantages and I have found that my experience there coincides with that of Mr. Jones, that where the jig is not too big and not very high, perhaps in a milling fixture, then we do get quite a satisfactory jig. But for anything over a reasonable size, say 2-ft. to 2-ft. 6-ins. I found tremendous amount of trouble and had to resort, despite many protestations from the firm, to the screw, and dowel method which was condemned by the customers.

MR. BLACKSHAW: I am sure we have all enjoyed the lecture Mr. Jones has given to us and we all appreciate the tremendous amount of work that is involved in the preparation of such a paper. In the short time of an hour it is exceedingly difficult to discuss all the pros and cons of jigs and it is in fact an almost impossible task. I do not think I need enlarge more in that respect. The controversy of the beeswax jig I will not say any more about except that there are quite a number of applications of it both in ordinary machining operations and in many cases of assembly fixtures, and jigs and fixtures do not necessarily stop at machining operations. One often finds a firm where they spend a tremendous amount of money and are enthusiastic that they shall have extremely rapid machining time, but they forget about the time and labour of assembling the job together. I propose a hearty vote of thanks to Mr. Jones for the most excellent lecture and for the able manner in which he has put it over.

MR. G. H. HALES (late Section President, who presided during the lecture and discussion) put the vote of thanks to the meeting.